

# Journal of the Royal Society of Arts

NO. 4963

FRIDAY, 28TH OCTOBER, 1955

VOL CIII

## FORTHCOMING MEETINGS

WEDNESDAY, 2ND NOVEMBER, at 2.30 p.m. INAUGURAL ADDRESS. '*Art in Education*', by R. W. Holland, O.B.E., M.A., M.Sc., LL.D., Chairman of the Council. Silver Medals which were awarded to lecturers in the last Session will afterwards be presented by the Chairman, and tea will then be served in the Library.

TUESDAY, 8TH NOVEMBER, at 5.15 p.m. COMMONWEALTH SECTION. '*The Gezira Scheme*', by Arthur Gaitskell, C.M.G., late Chairman and Managing Director, Sudan Gezira Board. Lt.-Col. Sir Stewart Symes, G.B.E., K.C.M.G., D.S.O., late Governor-General of the Sudan, in the Chair. Tea (for which there is no longer any charge) will be served from 4.30 p.m. in the Library.

WEDNESDAY, 9TH NOVEMBER, at 2.30 p.m. '*John Flaxman (1755-1826)*', by John Thomas, M.A., Ph.D. Professor A. E. Richardson, F.R.I.B.A., President of the Royal Academy of Arts, in the Chair. (The paper will be illustrated with lantern slides and by a small exhibition of Flaxman's work in the Library.)

WEDNESDAY, 16TH NOVEMBER, at 2.30 p.m. '*Public Relations and Advertising To-day*', by Sir Stephen Tallents, K.C.M.G., C.B., C.B.E., a Member of Council of the Society. Sir Miles Thomas, D.F.C., Chairman, British Overseas Airways Corporation, in the Chair.

MONDAY, 21ST NOVEMBER, at 6 p.m. The first of three CANTOR LECTURES ON '*The Science of Brewing*', by A. H. Cook, D.Sc., F.R.I.C., F.R.S., Assistant Director, the Brewing Research Industry Foundation. (See syllabus below.)

WEDNESDAY, 23RD NOVEMBER, at 2.30 p.m. E. FRANKLAND ARMSTRONG MEMORIAL LECTURE. '*Research in Industry*', by B. K. Blount, M.A., B.Sc., D.Phil.Nat., F.R.I.C., Deputy Secretary, Department of Scientific and Industrial Research. R. Holroyd, M.Sc., Ph.D., Director of Research, Imperial Chemical Industries, Ltd., in the Chair.

THURSDAY, 24TH NOVEMBER, at 4.30 p.m. COMMONWEALTH SECTION. (Joint Meeting with the East India Association and the Pakistan Society.) The Right Honble. The Earl of Home, P.C., Secretary of State for Commonwealth Relations, will give an account of his Commonwealth Tour. The Right Honble. Sir Patrick Spens, K.B.E., Q.C., M.P., President, East India Association, in the Chair. (Tea will be served from 4 p.m.)

*Fellows are entitled to attend any of the above meetings without tickets and may also bring two guests. When they cannot accompany their guests, Fellows may give them special passes, books of which can be obtained on application to the Secretary.*

#### SYLLABUS OF CANTOR LECTURES ON 'THE SCIENCE OF BREWING'

LECTURE 1. *Monday, 21st November. Barley, Malt and the Malting Process:* Historical background; carbohydrates, proteins and enzymes of barley and malt; scientific basis of malting; development and evaluation of improved barleys.

LECTURE 2. *Monday, 28th November. The Brewing Process and the Chemistry of Hops:* Mashing; hop boiling; selection and treatment of hops; chemistry of hop resins.

LECTURE 3. *Monday, 5th December. Yeast, Fermentation and Finished Beer:* Selection of yeasts; fermentation and fermentative properties; flocculence; spoilage yeasts and bacteria; pasteurization; biological and non-biological stability of beer; foam characteristics.

#### MARKET RESEARCH CONFERENCE

As previously announced in the *Journal*, the Conference on 'Market Research: fact-finding as a practical aid to overseas sales', will be held in the Lecture Hall on Tuesday, 15th November, 1955.

The programme for the Conference will consist of a morning and an afternoon Session. The morning Session, for which Sir Ernest Goodale, C.B.E., M.C., will be in the Chair, will consist of two papers. The first of these will be 'A review of the present export situation', by Mr. J. L. S. Steel, Chairman of the British National Committee of the International Chamber of Commerce and of the Overseas Trade Policy Committee of the Federation of British Industries; and the second on 'The possibilities and problems of Market Research', by Mr. Martin Maddan, M.P. There will then be a discussion on these papers.

At the afternoon Session, during which Mr. Leslie Gamage, M.C., President of the Institute of Export and Chairman of the Export Trade Promotion Committee of the Federation of British Industries will take the Chair, two case histories will be given. The first will be 'An application of Market Research in the consumer goods industry', by Mr. Alastair Sedgwick, Advertising Manager, Gillette Industries, Ltd.; and the second, 'An application of Market Research in heavy industry', by Mr. R. M. Davenport, Managing Director of Messrs. Shelvoke & Drewry, Ltd.; a discussion of the two case histories will follow.

Finally there will be a Brains Trust to discuss questions raised by the Conference. The question master will be Mr. Roger Falk, O.B.E., and the members of the panel, Mr. P. Harris, Mr. A. G. Jones, Mr. D. Lowe-Watson and Mr. R. L. Wills.

All tickets for the Conference have now been issued. A report of the proceedings will be published in the *Journal* in due course.

### THE LIBRARY

The resignation of the Librarian, Miss M. L. Clark, which has already been announced, took effect at the end of September and the Council have now appointed the Society's archivist, Mr. D. G. C. Allan, M.Sc.(Econ.), as temporary Curator-Librarian as from 1st October.

### ADDITIONAL HONORARY CORRESPONDING MEMBERS IN CANADA

The Council have recently been giving special attention, in consultation with the Honorary Corresponding Member, Colonel W. J. Brown, to the Society's affairs in Canada, with a view to extending the Society's usefulness to and membership in the Dominion, and as a first step they have decided to appoint two additional Honorary Corresponding Members, to act in Toronto and district and the Maritime Provinces respectively. They are:

Mr. Stanley Nesbitt Conder, LL.B.,  
1580 Winterhaven Road,  
Port Credit, Ontario.

and Professor Richard L. de C. H. Saunders, M.D., F.R.S.E.,  
96 Robie Street,  
Halifax, Nova Scotia.

Colonel Brown will continue to act for Canada generally, and it may be convenient to mention that he should be addressed as follows:

Colonel W. J. Brown, V.D., LL.D., J.P.,  
1006 Wellington Street,  
London, Ontario,

### PURCHASE TAX ON MEDALS

When opening the Society's recent Exhibition of European Medals, 1930-1955, the President of the Royal Academy referred to the serious inhibiting effect of purchase tax on this form of art, and the Special Activities Committee, reviewing this remark of Professor Richardson's at a meeting shortly afterwards, recommended to the Council that this was a matter in which the Society might appropriately take action.

Representations were accordingly made by the Society to the Board of Trade and to Customs & Excise, and the President of the Royal Academy and the President of the Royal Society of British Sculptors were very glad to lend their support.

The representations regarding medals struck in precious metals were considered by the Chancellor of the Exchequer, but unfortunately he decided that it would not be justifiable to deal with medals in isolation from other articles made in precious metals, all of which are at present chargeable with tax at the rate of fifty per cent under Group 27 of the Purchase Tax Schedule. The Chancellor, however, undertook to bear this matter in mind when he next reviewed the level of the tax in this sector.

In regard to medals struck in bronze and other non-precious metals the Society's action has resulted in a clarification of the position, which hitherto some artists and manufacturers had found obscure. Medals made in these metals are not chargeable with tax unless they are designed for personal adornment, which, in fact, means unless they incorporate some form of mounting which enables them to be worn on the person.

#### NEW EDITION OF LIST OF FELLOWS

As was announced in the *Journal* of 30th September, a new edition of the list of Fellows, corrected to 30th November, 1954, is now ready, and copies will be sent free of charge to Fellows who apply for them. In addition to the alphabetical section, the list contains a geographical index.

#### SESSIONAL ARRANGEMENTS

A supplement giving a list of the meetings so far arranged for the present session is included with this issue of the *Journal*.

#### MEETING OF COUNCIL

A meeting of Council was held on Monday, 10th October, 1955. Present: Dr. R. W. Holland (in the Chair); Dr. W. Greenhouse Allt; Mr. F. H. Andrews; Sir Alfred Bosson; Sir Edward Crowe; Mr. Robin Darwin; Mr. John Gloag; Sir Ernest Goodale; Mr. William Johnstone; Lord Latham; Sir Harry Lindsay; Mr. F. A. Mercer; Mr. Oswald P. Milne; Lord Nathan; Sir William Ogg; Mr. A. R. N. Roberts; Mr. E. Munro Runtz; Sir Harold Saunders; Sir Selwyn Selwyn-Clarke; Sir John Simonsen; Sir Griffith Williams, and Miss Anna Zinkaisen; with Mr. K. W. Luckhurst (Secretary), Mr. R. V. C. Cleveland-Stevens (Deputy Secretary) and Mr. David Lea (Assistant Secretary).

#### NEW MEMBERS OF COUNCIL

Professor Sir Charles Dodds, M.V.O., F.R.C.P., F.R.S., and Mrs. Mary Adams, O.B.E., M.Sc., were appointed Members of Council to fill vacancies created by the death of Lord Horder and the resignation of Mr. William Will.

## ELECTIONS

The following candidates, whose applications had been received since the last meeting in July, were duly elected Fellows of the Society:

- Acton, Maurice Francis, Buckingham.  
 Anderson, William George Deane, B.A., A.R.I.B.A., Lakeside, Cape Province, South Africa.  
 Badger, Professor Geoffrey Malcolm, D.Sc., Ph.D., Adelaide, South Australia.  
 Bannister, Frank Walker, B.A., Colne, Lanes.  
 Bolton, Geoffrey Oswald Douglas, Shipley, Yorks.  
 Brayshaw, Kenneth, Withington, Manchester.  
 Brown, Harry Clifford, B.S., Morristown, New Jersey, U.S.A.  
 Byrne, Gavin Francis, Hawthorn, Victoria, Australia.  
 Byrne, Thomas Joseph, Port Moresby, Papua.  
 Campbell, Archibald, C.B.E., M.I.Mech.E., Carshalton, Surrey.  
 Carling, Dennis Rock, M.A., M.I.Mech.E., Rugby, Warwicks.  
 Carson-Cooling, George, M.Sc., Brisbane, Australia.  
 Chappelow, Allan Gordon, M.A., London.  
 Cobbett, Cyril Henry, L.C.P., Norwich, Norfolk.  
 Collins, Leslie Hubert Bennet, A.R.C.A., A.T.D., Totnes, Devon.  
 Cork, Robert Alfred John, A.M.I.C.E., M.I.Mun.E., Chichester, Sussex.  
 Crompton, Oswald James, M.I.E.E., Amersham, Bucks.  
 Currie, James, O.B.E., M.A., London.  
 Daniel, Alfred Taylor, Barnt Green, Warwicks.  
 Dawson, Harold Morgan, Barry, Glamorgan.  
 Douglas, Claude Gordon, C.M.G., M.C., D.M., F.R.S., Oxford.  
 Doyle, Douglas James Robertson, Sydney, N.S.W., Australia.  
 Fairchild, Hurlstone, Tucson, Arizona, U.S.A.  
 Fitz-Gibbon, William Gerald, Hatfield, Herts.  
 Franklin, Harry, A.R.I.B.A., Tadcaster, Yorks.  
 Gardner, William Maving, A.R.C.A., Wittersham, Kent.  
 Ghosh, Niren, Darjeeling, India.  
 Goldsmith, Maurice, B.Sc., London.  
 Graham, Mrs. Rosemary Anne, London.  
 Guillemin, Professor Ernst A., S.M., Ph.D., Cambridge, Massachusetts, U.S.A.  
 Gulick, Professor Addison, A.M., Ph.D., Cambridge, Massachusetts, U.S.A.  
 Gupta, Professor Prodosh Kusum Das, Calcutta, India.  
 Guphill, Arthur Leighton, Stamford, Connecticut, U.S.A.  
 Hall, Ernest Arthur, New Malden, Surrey.  
 Harrison, John Frederic, M.I.Mech.E., Belper, Derbys.  
 Harvey, Ranald John, M.I.C.E., M.I.Mech.E., M.I.E.E., London.  
 Haut, Frederick Joseph George, B.Sc., A.M.I.Mech.E., Purley, Surrey.  
 Hildred, Sir William Percival, C.B., O.B.E., Montreal, Quebec, Canada.  
 Hendrick, Thomas William, Teddington, Middx.  
 Holledge, Bryan Raymond, A.R.C.A., London.  
 Hoswell, Francis James, Des.R.C.A., Bradford, Yorks.  
 Hunt, John Warner, A.L.A., Colchester, Essex.  
 Isherwood, James Lawrence, Wigan, Lanes.  
 Jackman, Richard Harry, B.Sc., Ph.D., Hamilton, New Zealand.  
 Jeffrey, John Edward, Mapperley, Nottingham.  
 Jennings, Cyril Oswald, M.B.E., A.R.I.B.A., F.I.A.A., Kuala Lumpur, Malaya.  
 Jordan, Edward Francis, B.S., Norwichtown, Connecticut, U.S.A.  
 Kirkwood, James Richard, Petts Wood, Kent.  
 Logan, Alexander, A.M.I.E.E., M.Amer.I.E.E., Dunoon, Argyll.

Langley, Eccabot Paul, Pretoria, Transvaal, South Africa.  
 Lyon, Miss Laura Fraser, San José, Costa Rica, Central America.  
 Maitland, John Pelham, M.B.E., F.S.A., Sevenoaks, Kent.  
 Manning, Humphrey Davys, B.Sc., M.I.C.E., London.  
 Manser, Albert William, B.Sc., M.I.Mech.E., London.  
 Marshall, Frederick George, Sutton, Surrey.  
 Moores, John, Formby, Lincs.  
 Nash, William George, Southampton, Hants.  
 Nesbitt, Ulric Osmond, Port-of-Spain, Trinidad, B.W.I.  
 Nickson, Richard Scholefield, M.A., F.R.I.B.A., London.  
 Penrose, Charles, B.Sc., E.E., LL.D., D.Eng., Litt.D., L.H.D., West Chester, Pennsylvania, U.S.A.  
 Procter, Mrs. Margery, Blackburn, Lincs.  
 Pryer, Leslie James Howard, London.  
 Read, Leonard Ralph, B.A., London.  
 Rendell, Mrs. Maureen Kathleen Patricia, Johannesburg, South Africa.  
 Rewald, John, Ph.D., New York, U.S.A.  
 Rootes, Sir Reginald, Langley, Kent.  
 Savage, William, Ombe River, Southern Cameroons, West Africa.  
 Schröder, Otto Edward Henry, Windhoek, South West Africa.  
 Simmons, Miss Ann Margaret, Hessle, Yorks.  
 Sheets, Mrs. Nan, Oklahoma City, Oklahoma, U.S.A.  
 Smith, Eric Arthur, D.Mus., F.R.C.O., F.T.C.L., Edinburgh.  
 Soysa, Andrew William Ernest, O.B.E., F.R.C.P.E., F.L.S., Colombo, Ceylon.  
 Straker, Edwin John, Newcastle-upon-Tyne.  
 Stubbs, Leonard George, Leigh-on-Sea, Essex.  
 Teğul, Bayan Sabire, Istanbul, Turkey.  
 Thaung, U Hla, Rangoon, Burma.  
 Thomas, Herbert Gregory, M.A., New York, U.S.A.  
 Trask, Eric Darien, M.I.Mech.E., London.  
 Tritton, Julian Seymour, M.I.C.E., M.I.Mech.E., Esher, Surrey.  
 Waters, Alwyn Brunow, M.B.E., G.M., F.R.I.B.A., London.  
 We, U Nyunt, Rangoon, Burma.  
 Wild, Ronald Stanley, Singapore.

The following has been elected an Associate Member as an Examinations Silver Medallist:

Beecham, Alan, Boston, Lincs.

The following has been admitted as an Institution in Union under Bye-Law 66:

Display Producers and Screen Printers Association, London.

#### OVERSEAS ACTIVITIES

A report from a committee appointed earlier in the year to consider the Society's activities overseas was considered and adopted, and new appointments of Honorary Corresponding Members were made in accordance with the Committee's recommendations (see separate announcement).

#### OTHER BUSINESS

A quantity of financial and other business was transacted.

# STONE IN ARCHITECTURE

*Three Cantor Lectures*

## I. STONE AS A BUILDING MATERIAL

*by*

*R. J. SCHAFFER, B.Sc., M.A.,  
of the Building Research Station, Department  
of Scientific and Industrial Research.*

*Monday, 2nd May, 1955.*

### INTRODUCTION

The subject of building stone has engaged the attention of this Society on many previous occasions. But whereas the references in earlier transactions are to the invention of machines for quarrying and working stone or to particular quarries, papers that have appeared since about the middle of the nineteenth century are mainly concerned with the use of stone, its suitability for its purpose or its maintenance and preservation. This change in outlook can be ascribed in part to the public interest aroused by the rebuilding of the Houses of Parliament between 1839 and 1851, and to the enquiries that followed when signs of deterioration were reported to have become apparent in the stone shortly after the completion of the building.

In this century, papers have been read to the Society on stone preservatives and on the preservation of ancient monuments and historic buildings. These titles are indicative of our sense of responsibility for the care of old buildings. The mediæval mason had no compunction about demolishing the work of his predecessors to make way for a new style, and subsequent centuries have treated old buildings with scant respect. We now consider it our duty to conserve what remains of the original work wherever possible. But we are not concerned solely with ancient buildings. Stone has to be chosen and used appropriately, whether for new buildings or for the repair of old ones. Buildings, old and new, need care and maintenance. In the study of building stone in the laboratory and in the field the aim is to understand the relationship between the measurable properties of the stone and its resistance to the weathering agencies to which it is exposed, and to eliminate avoidable causes of deterioration and unsuitable methods of maintenance.

### CLASSIFICATION AND GENERAL CHARACTERISTICS

The rocks that provide our building stones are of two kinds—the primary

or igneous rocks (such as granite), which were formed by the cooling and solidification of a molten magma, and the secondary or sedimentary rocks, limestones and sandstones, which have been formed by the disintegration and decomposition of the primary rocks and the subsequent deposition and consolidation of the products in a stratified form. The folding and faulting of the rocks and their denudation by weathering have made them accessible to quarrying. Where the rocks have been subjected to heat and pressure the original structure may be wholly or partially obliterated. In this way slate has been formed from clay or volcanic ash, marble from limestone. Details of the classification and petrology of rocks are to be found in text books. The scientific names and those customarily used in commerce and industry are being defined in a British Standard now in preparation.

Rocks of all kinds have been used for local building, but of the igneous rocks in this country only the granites, which are found in Scotland, in the Lake District, and in Devon and Cornwall, have been transported long distances. Granite is used for the plinths of important buildings, less often for the whole façade, and it finds use as polished slabs for facing shop fronts and offices. Its main constructional use has been for civil engineering work in docks and bridges.

Of sedimentary rocks we have a very wide variety, because the geological structure of this island is such that there are outcrops of rock of almost every geological age. Thousands of quarries have been opened. Some have been worked out or abandoned. Some have turned to the production of concrete aggregate or roadstone, but there are still large numbers that produce building stone. Broadly speaking, the main sources of sandstone are in the northern counties of England and in Scotland, and of limestone in the Jurassic belt that stretches from Portland, through Bath and the Cotswolds, Northamptonshire, Rutland, Lincolnshire and into Yorkshire. Magnesian limestones are quarried in a narrow outcrop of Permian age extending northwards from Nottingham to County Durham. But, besides all these, some well-known varieties come from other areas. Totternhoe stone from the lower chalk in Bedfordshire, Kentish rag from the Lower Greensand, and Reigate stone from the Upper Greensand supplied the southern counties for centuries. In East Anglia, flint was largely used.

Sandstones consist essentially of grains of quartz, with other weather-resistant minerals derived from the primary rocks from which they were formed. They range in texture from coarse to very fine and the sand grains may be cemented together with siliceous matter, with iron compounds, with carbonates or with clay. The character of the cementitious material determines the colour and also the durability, the latter depending primarily on the resistance of the cement to the effects of water and dilute acids, the sand grains themselves being virtually indestructible. Some sandstones were formed from wind-borne deposits. These are recognizable under the microscope by the rounded shape of the sand grains.

Limestones consist essentially of calcium carbonate formed either by precipitation from sea water as rounded (oolitic) grains, or by the accumulation of the shells and skeletons of marine organisms. These deposits have become cemented together by the deposition of calcium carbonate from solution.

Magnesian limestones contain a proportion of magnesium carbonate. Some are composed largely of organic remains; some are oolitic; some consist predominantly of crystals of dolomite, the double carbonate of lime and magnesia. Among limestones, differences in durability are related to their pore structure rather than to their chemical composition.

The sedimentary rocks, having been deposited in successive layers, show a more or less well-defined plane of stratification, described as the 'natural bed'. In some kinds, the direction of the bed is revealed in the quarried block by variations in the colour or texture of successive deposits, or by the orientation of flakes of mica or flat shell fragments, parallel to the bed. In some, the bed is hard to determine unless the block is marked before it leaves the quarry.

It is always said that stone should never be face-bedded (the bed lying parallel to the face of the wall) but should be laid on its natural bed except in cornices, copings and string courses, where joint-bedding, with the bed parallel to the vertical joints, is sometimes preferable. It is well to observe this rule in laying most kinds of sandstone and for a limestone like Ham Hill stone in which seams of good limestone alternate with thin seams of clay; it is less important for stones of more uniform structure. In St. Paul's Cathedral there are blocks of Portland stone to be seen that are none the worse for having been face-bedded. Scaling of the exposed face is not always a sign of face-bedding; scaling can occur in cylindrical columns and on two faces of a quoin.

Micaceous sandstones can readily be split parallel to the bed for use as paving stones and roofing slabs. The limestones of Collyweston and Stonesfield, which have also been used as roofing slates, show alternations in the structure of the successive layers. These cannot be split until they have been exposed to frost.

Slate is quarried in Wales, in the Lake District, in Cornwall, and in parts of Scotland. Its main use is for the production of roofing slates. The line of cleavage is at right angles to the direction of the earth pressure to which the rock was subjected and is independent of the bedding of the sedimentary deposits from which the slate was formed. Block slate has been used for building, but, as with other non-absorptive materials, it is difficult to prevent the penetration of rain water through the joints. In the Lake District the traditional practice is to cant the horizontal joints towards the outer face of the wall. Slate-hanging on external walls is practised in some areas.

#### HISTORICAL

From the earliest times stone has been used as a building material wherever it has been available near at hand or wherever there has been a sufficient motive for carrying it. While our thoughts turn naturally to the world-famous monuments of ancient Egypt, we need not go so far afield for early examples, for we have our own survivals of the use of stone in antiquity in numerous prehistoric stone circles. At Stonehenge, the working of the mortices and the dressing of the lintels to the curvature of the circle bear witness to the skill of those who under-

took its construction. The late Dr. H. H. Thomas, of the Geological Survey, established that the smaller blocks (of a bluish dolerite), must have been brought from Prescelly in South Wales and it is thought that these may have formed part of an even earlier structure. The massive trilithons are of fine-grained sandstone of remarkable durability; there is scarcely any sign of deterioration, despite their having been exposed to the weather for some 3,000 to 4,000 years. Other prehistoric survivals of the use of stone are found in pit dwellings and in the crude stone chambers of burial mounds.

Of later date, around 100 B.C.—A.D. 100, are the stone dwellings of Skara Brae in the Orkneys, and the circular dwellings and the circular, tower-like *brochs* of northern Scotland and the adjoining islands. The vitrified forts of Scotland, in which the blocks of stone have been fused together by heat, probably as the result of conflagration, and stone-revetted forts, like that at Stanwick in Yorkshire, are of similar age.

The Romans brought marble from Italy for decorative work, but found and used native stone for general building. They used local stones for Hadrian's wall, for example, others for the walls of Chester and of York, and they brought stone up the Medway from Kent to build the walls of London. Blocks of oolitic limestone of more than one kind found on the site of Verulamium and on other neighbouring Roman sites must have been brought from far afield, some almost certainly from the district of Stamford, others probably from the Cotswolds.

Surviving Saxon churches and Saxon crosses illustrate the continued use of stone during the Dark Ages. The Norman invasion brought a new impetus which led to the great era of mediæval architecture from the eleventh century to the beginning of the sixteenth century, during which time stone was the pre-eminent building material. The cathedrals of York, Wells, Lincoln, Exeter, Chester, and Carlisle all exemplify the mediæval use of stone from local sources. Stone was also carried over considerable distances where the situation demanded it. Supplies for Windsor Castle were drawn from Kent, Bedfordshire, Oxfordshire and Yorkshire. Caen stone from Normandy was very widely used. Reigate stone for Westminster Abbey was carried overland to Battersea, and marble was brought from the Isle of Purbeck, which was also the centre of a widespread trade in marble effigies. Henry VII's chapel at Westminster, the last and crowning achievement of this period, was completed in 1509, using Caen stone, since renewed in Bath stone, on a plinth of Kentish rag; the vaulted roof is built of limestone from Oxfordshire.

Portland stone, now the most widely used of British building stones, did not come into general use until the seventeenth century, though it was known long before then. There are Roman coffins of Portland stone in the museum at Easton and the eleventh-century ruins of Rufus Castle still stand on the Isle of Portland. A fourteenth-century inventory of the stock of stone in hand for the repair of London Bridge (built in 1171 of Kentish rag and Reigate stone) includes 'Porteland' stone. It is not beyond the bounds of possibility that the few blocks of Portland stone to be seen mixed with the Kentish rag stone used in the fourteenth-century precinct wall of Westminster Abbey may have come from

the supply recorded as having been obtained in the reign of Edward III for repairing the river wall of the Palace of Westminster. The development of the stone resources of the Isle of Portland dates from 1619 when Inigo Jones chose Portland stone for the Banqueting Hall (now the United Services Museum). This building, intended to form part of a new Palace of Whitehall projected by James I, marks the introduction of the Classical style of architecture into England. Inigo Jones used Portland stone again, shortly afterwards, for the York Water Gate, which still stands, now high and dry, in the Embankment Gardens. In 1633 he undertook the refacing of Old St. Paul's and built a new portico in the classical style, which, incongruous though the illustrations of it look to-day, was greatly lamented by John Evelyn when it was destroyed in the Fire of London in 1666. Wren's use of Portland stone for rebuilding St. Paul's Cathedral and other city churches after the fire established its reputation as a limestone having excellent weathering qualities, even in heavily-polluted atmospheres. The appearance of the stone of finer texture obtained from the Whit and Base beds has generally been preferred. Nevertheless, it is to be regretted that more use has not been made of the coarser stone from the Roach bed. The almost perfect condition of the eighteenth-century Church of St. George in the Isle of Portland demonstrates that its qualities are beyond reproach.

The construction of the canals and railways facilitated the distribution of building stones. With the development of road transport, circumstances now operate to the disadvantage of stone. Local needs used to be supplied from local resources. Stone was used for housing wherever it was available, and each area developed its own style of building to suit the stone at hand. Bricks and concrete blocks are now imported into districts where the towns and villages have hitherto been built in stone, and an indiscriminate use of these materials tends to detract from the picturesque character of the countryside in these areas.

Except in favourable circumstances, where off-cuts are readily available and where individual architects have applied themselves to the task of building in stone at competitive prices, the cost is higher than for brick. Enquiries have shown that there is scope for some degree of economy in construction and in the simplification of the traditional procedures and it is hoped that the cost can be reduced to some extent. But it is not enough to use stone for its own sake. The most successful results have been achieved where the use of stone has been combined with sympathetic regard to the design of the houses and the planning of the scheme as a whole. It is heartening to note that Section 39 of the Housing Act of 1949 provides for the granting of an increased subsidy where the Minister is satisfied that additional expense is incurred to preserve the character of the surroundings.

#### CONSTRUCTION

The manner in which stone is used for building is determined by the thickness of the beds in the quarry, by the working qualities of the stone and by the type of building for which it is intended. Broadly, we distinguish between ashlar

masonry, in which each block is dressed to precise rectangular dimensions, and rubble masonry, of which there are several variants, in which the blocks are only roughly dressed to shape. There is a British Standard Code of Practice for each.

To economize in labour and material, it was once the normal practice to face masonry walls with dressed stone and to fill the space between with mortar and spalls of stone. That may be one reason why we read so often of the collapse of walls and towers in mediaeval times. It is only a few years since the piers of St. Paul's Cathedral had to be strengthened when it was found that the weight of the dome was being carried on thin ashlar facings. Modern ashlar uses courses of stone, alternately  $4\frac{1}{2}$  and 9 inches thick, backed with solid brickwork, the heights of courses being designed to match the height of two, three or more courses of brick. In steel-framed construction, the frame carries the structural loads and much of the masonry is held in position with cramps and bolts. The most recent technique resembles that normally used for marble, the stone being used as a cladding. Waterloo Bridge is a reinforced concrete structure faced with thick slabs of Portland stone. Thinner stone veneer was used in parts of the Festival Hall and this technique has been adopted for some of the newer schools. Increase in the size and power of the machinery used facilitates the preparation of the stone in large and relatively thin slabs, but new constructional problems are thereby introduced. The slabs may be more susceptible to damage in transport and questions arise on how they should be fixed, on what allowance should be made for thermal expansion, and on whether the joints can be maintained in a weathertight condition.

These new developments extend the scope for the use of stone, but it cannot be denied that the demand for it is less than it was. Stone will doubtless continue to hold its own for use in public buildings and important commercial buildings. The united efforts of architects, builders and quarry masters and full appreciation of its qualities by the general public will be required if it is to recover some measure of the tradition of its use in domestic buildings in the face of increasing competition from manufactured building materials.

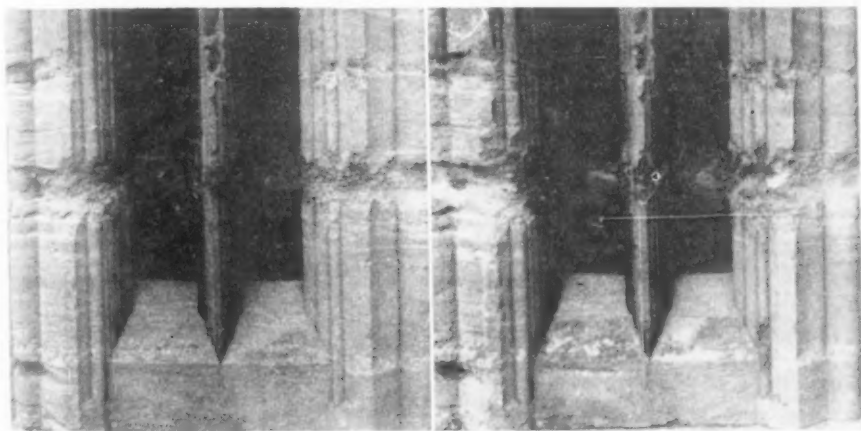
## II. THE WEATHERING, PRESERVATION AND RESTORATION OF STONE BUILDINGS

by

R. J. SCHAFFER, B.Sc., M.A.

*Monday, 9th May, 1955*

In speaking of the weathering, preservation and maintenance of stone buildings we can hardly avoid giving special attention to the defects that cause concern and need to be put right, but we must not lose sight of the good qualities of stone or forget that the effects of weathering are not altogether detrimental: stone buildings owe much of their attractiveness to the mellowing effects of time. Good stone, properly used, will endure for centuries. Ancient buildings now in ruin have lost more at the hands of those who used them as quarries than from the effects of time and weather. Some kinds of stone are more durable than others; some give better service in some circumstances than in others; defects can arise, as we shall see, from no fault of the stone but from the way in which it is used.



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FIGURE 1. *Cotswold limestone, probably sixteenth century; left, in 1926, and right in 1955*

Even stone of relatively poor quality will last for a surprisingly long time. Wren, in the early eighteenth century, describing his work on the restoration of Westminster Abbey, comments on the poor weathering qualities of the Reigate stone used in its construction in the thirteenth and fourteenth centuries and

speaks of having found it 'disfigured to the highest degree'. Some of it he 'invested with better stone . . . from the Quarries about Burford', but not all, for there are blocks of the original stone still to be seen, 250 years after his comments were made, and some six centuries after it was placed there.

It is also instructive to compare photographs of buildings taken at different times and to notice how slowly the appearance changes in the course of years (Figure 1). In such circumstances there is clearly no need to take hasty decisions in efforts to 'preserve' the stone from further decay. But in other circumstances fragments may be dangerously loose, or there may be serious penetration of water into the fabric. Prompt action is then called for.

The more important of the agencies that contribute to the disfiguration and decay of stone buildings are pollution of the atmosphere by smoke and sulphur fumes, contamination with soluble salts derived from extraneous sources, and frost, which affects only certain kinds of stone if they are used in the more vulnerable parts of buildings where they can become frozen in a highly-saturated condition. The effects of these agencies depend on the presence of water in large or small amount. Interior masonry becomes dingy but is much less subject to deterioration than exterior masonry. Decay of interior surfaces, when it occurs, is usually associated with the presence of soluble salts.

#### ATMOSPHERIC POLLUTION

Air-pollution and its cost to the community have been reviewed in the recently published report of the Beaver Committee, in which it is estimated that two million tons of smoke (carbonaceous matter) and over five million tons of sulphur

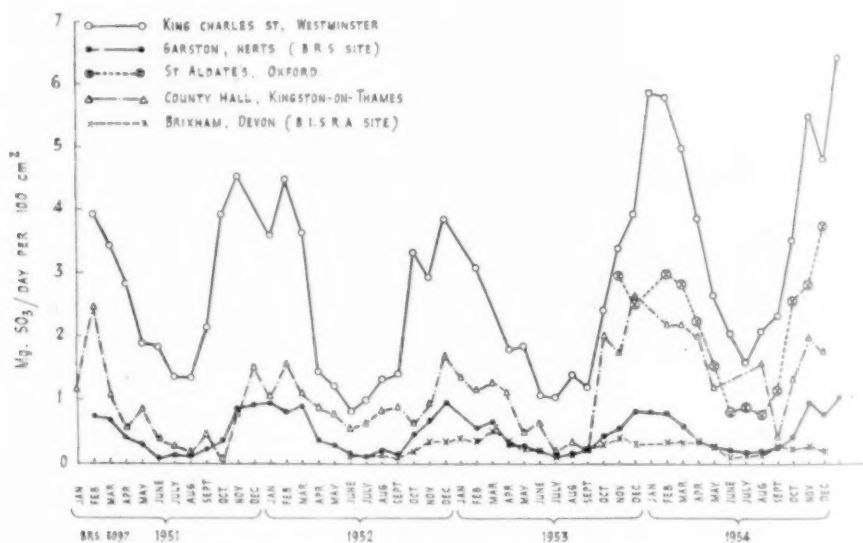


FIGURE 2. Typical records of air pollution by sulphur dioxide; lead peroxide method

dioxide were discharged into the atmosphere in this country in 1953. Industry is not wholly responsible. The domestic fire is the main offender in respect of the emission of smoke and takes a considerable share in the emission of sulphur dioxide, which is derived from the combustion of the sulphur compounds present in the fuel. Smokeless fuels, fuel oil, which is smokeless only if it is burned efficiently in suitable appliances, and coke, contain no less sulphur than coal, so that, even if the smoke problem can be solved by the provision of enough smokeless fuel to supersede the use of raw coal, there will be no prospect of abating the emission of sulphur dioxide unless means can be found for extracting the sulphur compounds from the fuel or preventing their emission in the flue gases. In large industrial installations, such as power stations, sulphur dioxide can be removed from the flue gases. Smoke emission from industrial boilers can be controlled by the use of proper equipment and proper methods of stoking. The domestic chimney is less easily controlled. While the problem of atmospheric pollution remains unsolved we are guilty of a prodigal waste of fuel and the consequent state of our buildings is only part of the penalty we pay. Figure 2 shows some typical records of sulphur dioxide pollution, measured by the standard lead peroxide method.

The effects of atmospheric pollution on building stone are of two kinds. Smoke adheres to and blackens the surfaces; sulphur dioxide, which dissolves in water to form sulphurous acid, reacts with limestones and with those sandstones (and roofing slates) that contain carbonates, eventually forming sulphates which cause consequential damage. These are no new problems. They were recognized long before the Industrial Revolution led to a spectacular increase in the use of coal and to the concentration of population in towns and cities, where the greater part of the emission of smoke and fumes takes place and where the effects are most prominently seen. But the effects are not confined to large cities; they manifest themselves in small, purely residential communities and to some extent in country districts. Sulphur dioxide is more widely disseminated than smoke. Atmospheric pollution records show that sulphur dioxide can be detected many miles downwind of the source and that sulphur compounds

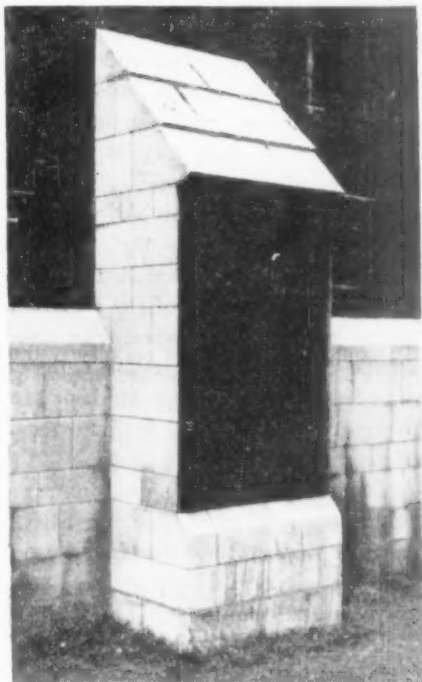


FIGURE 3. *Effect of rain-washing on limestone in a smoke-polluted atmosphere*

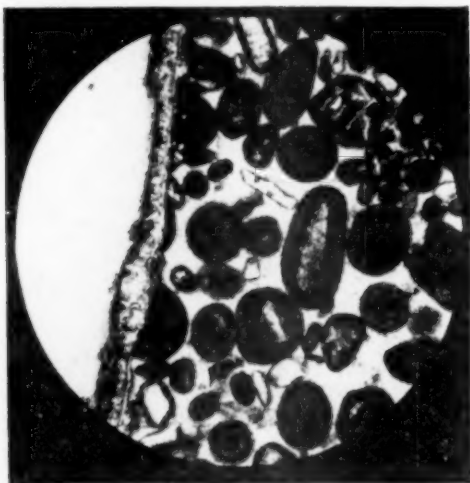


FIGURE 4. *Transverse section of weathered Bath stone; calcium sulphate (gypsum) crystals at surface with overlying film of soot*

may be present in rain water collected in places where the air is reasonably clean. Buildings in rural areas are cleaner than those in towns, but, even so, may still bear evidence of the effects of sulphur fumes.

The presence of sulphur acids in rain water accentuates its natural solvent action on limestones. The surfaces that are freely exposed to rain dissolve very slowly and soot cannot gain a foothold (Figure 3). That is why the weather sides and upper parts of limestone buildings are often so much cleaner than the sheltered surfaces. With good limestone, erosion of the rain-washed surfaces is of no serious

consequence and is advantageous in so far as it develops the texture of the stone, though carvings and statuary may in time become unduly weather-worn. The water that drains down the face of the building deposits black encrustations under the cornices and other projections. These consist of dust and soot cemented together with calcium carbonate and calcium sulphate.

When water evaporates from a porous material any soluble matter present in solution tends to be deposited at or near the evaporating surface. Calcium sulphate is not very soluble in water but it is soluble enough to have harmful effects. Its deposition at the face of a limestone (Figure 4) leads to the development of a hard skin which, far from protecting the stone, is liable to lead to blistering and scaling of the surface (Figure 5). Sandstones in which the sand grains are bound together with calcium carbonate are similarly affected and solution of this matrix leads to a loss in cohesion at a little distance behind the exposed surface. In some kinds of sandstone this latter effect occurs as a result of repeated wetting and drying even though there may be no significant amount of carbonate present.

The effect of sulphur fumes on magnesian limestone is to produce magnesium sulphate as well as calcium sulphate. Magnesium sulphate is more soluble than calcium sulphate and its effects can be even more serious. It accumulates in sheltered places and deep cavities may be formed in the stone by repeated solution and recrystallization.

Roofing slates containing carbonates deteriorate in polluted atmospheres. Deterioration takes place on the under surfaces and between the laps and the defects may pass unnoticed until the heads have decayed to such an extent that the slates slip out of position.

Sandstones of good quality, which are not themselves attacked directly by sulphur dioxide, may be damaged by the absorption of sulphates derived from neighbouring limestone. Bricks may also be affected, and the condition of the granite plinths of the Goldsmiths' Hall and of the Royal Exchange suggests that some kinds of granite are not immune.

Granites and sandstones exposed to a smoke-polluted atmosphere tend to become blackened all over by the deposition of soot. The black film adheres so tenaciously that such buildings are very difficult to clean. When Cleopatra's Needle was cleaned in 1948 the surface was found to be coated with a hard, black deposit of appreciable thickness which consisted essentially of carbonaceous matter and silica. It appears that, despite the low solubility of the siliceous constituents of the granite, enough silica is taken into solution to act as a cement for the sooty matter that collects on the surface. A similar process doubtless operates on sandstones, for it is the surfaces that are freely exposed to rain that become blackened first.

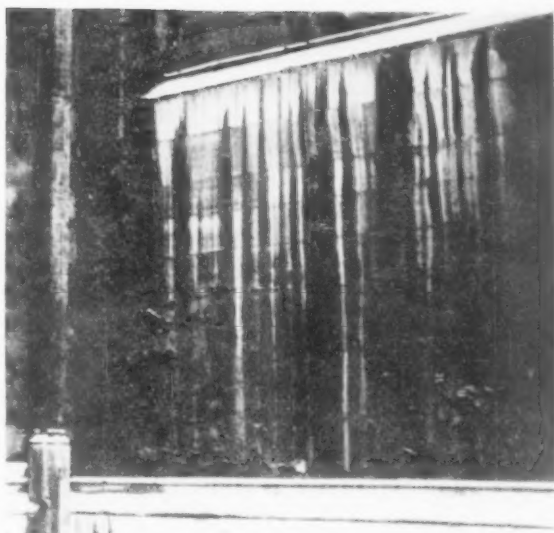


FIGURE 5. *Irregular downwash on limestone and blistering of sulphate skin*

#### FROST

Stone is not damaged by frost unless it is frozen in a highly saturated condition and there are many kinds that, in normal circumstances, are quite immune. Others are liable to be affected if they are used in positions in which they can become very wet (Figure 6 overleaf). Copings, sills, cornices and string courses are particularly vulnerable because they offer catchment surfaces to rain and may hold melting snow: retaining walls, walls without damp-proof courses, and plinths are also liable to be damaged. Plain wall surfaces are seldom affected, though a few cases came to notice during the severe winter of 1946-47, when frost damage occurred in buildings that had stood unharmed through many previous winters. The subject of freezing tests is discussed in a later paragraph.

#### SOLUBLE SALTS

The damaging effects of sulphur fumes on building stones are associated with the formation and crystallization of sulphates of calcium and magnesium. Soluble

salts derived from extraneous sources may be equally or even more detrimental. Some salts are more aggressive than others; some kinds of stone are more susceptible than others. However good the stone, it is well worthwhile to take every precaution to avoid salt contamination. The harmful effects are continuous and progressive.

There are many sources of contamination. Where there is no damp-proof course, the lower courses of masonry often show gross deterioration, because the absorption of moisture through the foundations introduces salts derived from the soil. The height to which the moisture rises is limited by the amount lost by evaporation from the surfaces, the maximum height being that at which there is a balance between the rate of loss by evaporation and the rate at which water can be drawn up by capillarity. Application of paint or other surface treatment, besides being inadequate to restrain the destructive effect of the salts, retards evaporation and drives the moisture to a higher level.

Similar difficulties arise if a damp-proof course is bridged with a porous mortar, or if soil is heaped against a wall, or if the street paving is laid above the level of the damp-proof course. This last is a very common fault and one that can easily be avoided. It is a good plan to use granite for the base course, especially if there is any doubt about the level at which the paving will be laid.

The penetration of rain water through defective joints, or through parapet walls not provided with damp-proof courses, or through cornices, sills and similar features, causes any salts that may be present in the backing materials to

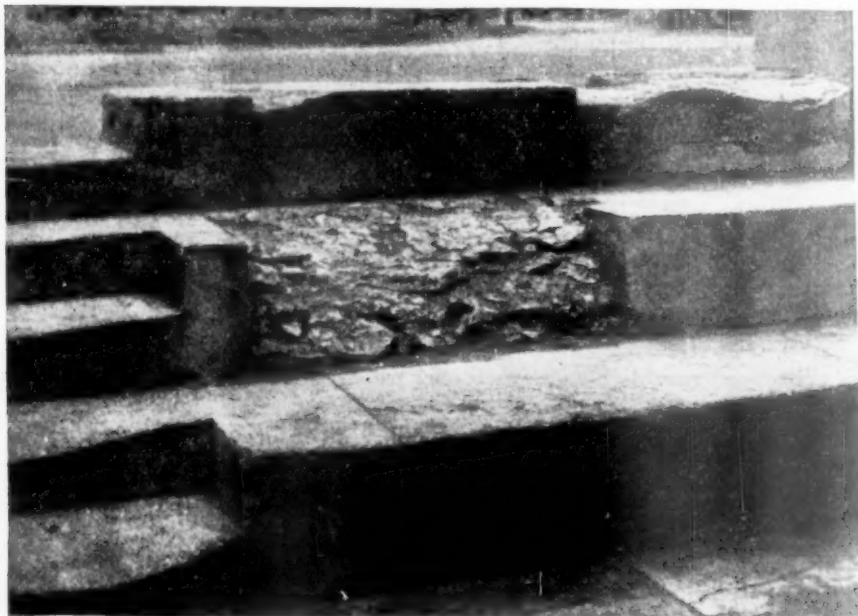


FIGURE 6. *Frost damage in limestone steps*

be transferred to the wall surfaces, where they can cause much damage and unsightliness inside the building as well as outside. Where the cause has been recognized the remedy will be obvious.

The use of caustic soda, washing soda or soda ash for cleaning buildings was at one time a common source of salt contamination. Much damage was caused (Figure 7) and there are buildings that were cleaned in this way many years ago in which the salts then introduced are still active. The use of household scouring powder for cleaning steps is liable to cause salt contamination and subsequent decay of door jambs and flanking walls.

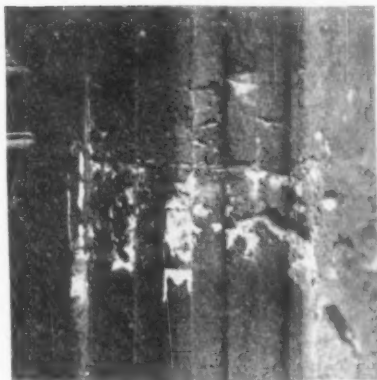


FIGURE 7. *Decay following the use of an alkaline cleaning agent*

The effects of contamination with chlorides can often be seen in buildings facing the sea, where there are sometimes striking differences in behaviour between stones of different kinds and even between individual blocks of the same kind. Similar defects in widely-separated buildings have followed the distribution of stone that has been accidentally contaminated with sea-water. The harmful effect of chlorides also shows itself in places where salt meat has been stored. There is an example in the vestibule of the Divinity Schools in Oxford, which is still popularly known as the Pig Market, recalling the use to which the building was put after the Reformation. Several other cases have come to notice (for example that shown in Figure 8 overleaf) and it is suspected that this was the cause of decay that occurred in parts of the inner face of the West Wall of Westminster Hall, which was refaced with Ketton stone by Pearson in the eighties of the last century. As early as 1890 a question was asked in Parliament about why the new stone had begun to decay in the same places as before. No explanation was offered at the time. When the building was examined in 1930 the affected areas were still crumbling slowly and continuously. Much chloride was found there in the decaying areas and virtually none elsewhere. The origin of the salt has not been established, but the probability is that the affected areas were the sites of butchers' booths in the days when Westminster Hall was used as a market place. When the wall was repaired, precautions were taken to isolate the new stone from the masonry behind it.

Salt will preserve meat; some have thought that it might preserve stone. A salt wash is known to have been applied with that intention to the interior masonry of a church in East Anglia, where there has since been a steady disintegration of the contaminated surfaces. Similar disintegration occurs in a mediæval monument where it is suspected that the chlorides present have a similar origin.

#### MICRO-ORGANISMS

The bacterial hypothesis of stone decay deserves mention, not because

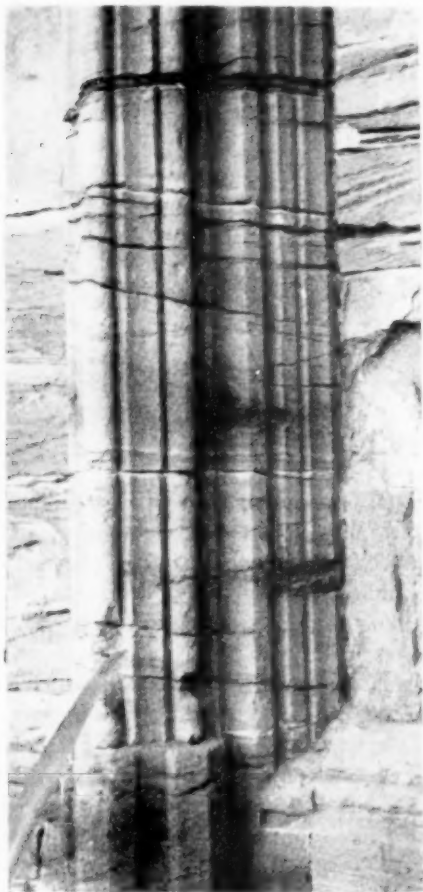


FIGURE 8. *Chlorides introduced by storage of salt meat*

micro-organisms are known to play a significant part in the processes involved, but because the hypothesis has repeatedly been revived on the basis of insufficient observation and experiment. The observation that isolated patches of decay tend to grow larger as time goes on is often cited in support of the suggestion that stone decay is caused by micro-organisms, but that line of argument carries no weight because soluble salts spread in a porous material and can have precisely the same effect. Nor does the cultivation of nitrifying organisms or sulphur-oxidizing organisms from a sample of decaying stone afford any proof that the organisms were present in an active state and contributing to the processes of decay. Another supposition, that there may be a symbiotic relationship between sulphur-oxidizing and sulphate-reducing organisms, making a limited supply of sulphur continuously re-available to form acids to react with the stone, rests on an insecure foundation, because the reducing organisms are anaerobic.

The role of micro-organisms was studied at length by the late Professor S. G. Paine on behalf of the Building Research Board between 1924 and

1935. He found that nitrifying organisms, sulphur-oxidizing and sulphate-reducing organisms could be cultivated by inoculating appropriate media with scrapings of weathered stone from buildings. When the nitrifying and sulphur-oxidizing organisms were supplied with a suitable nutrient the acids produced by their metabolism naturally caused erosion of the surfaces of blocks of limestone in contact with them. Sulphur-oxidizing organisms were first found in one of the decaying areas, just mentioned, in Westminster Hall. But, whereas the sound and decaying areas were clearly differentiated in chloride content, the organisms were not always found in the decaying areas and were not always absent from the sound areas. Elsewhere, too, sulphur-oxidizing organisms could be found in sound as well as in decaying stone and even in dust collected from the surfaces of other materials. Since these (and nitrifying) organisms are normally present

in the soil it is hardly surprising that they should be found on the surfaces of buildings.

It is known that sulphur-organisms play a prominent part in promoting the corrosion of concrete pipes carrying decomposing sewage and of metals underground. There is as yet no convincing evidence that they play a significant part as causative agents of stone decay. If micro-organisms play a part at all there can be no question of their being the only cause.

About two years ago there were newspaper reports stating that buildings in Venice were being attacked by 'the dreaded stone disease', but no information was given, and none has come to hand since, to show what inspired this phrase. The buildings there (Figure 9) are so much affected by the absorption of water and salts through the foundations that it is hardly necessary to look for a further explanation. It may be that the phrase used was intended only as a figure of speech.

#### STONE PRESERVATIVES

A good oil paint, properly applied when the stone is suitably dry, will protect

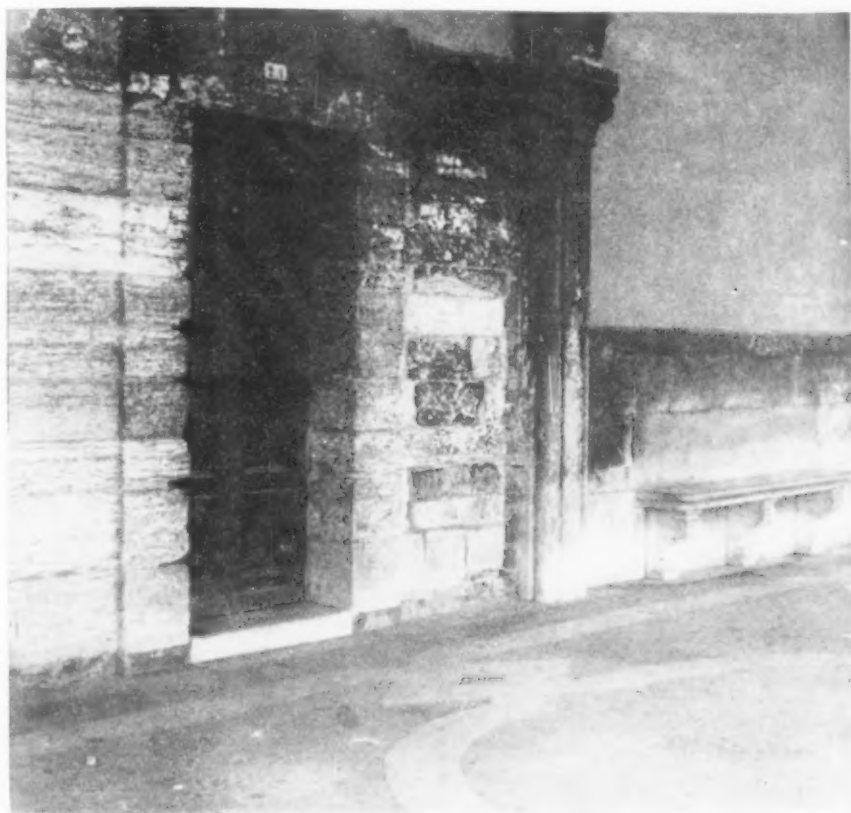


FIGURE 9. *Salt-contamination in Venice*

stone from decay as long as the paint is well-maintained and provided also that no moisture finds its way behind the paint film. Painting is not an acceptable means of preserving important buildings, and there has been, over the past 130 years or more, a succession of proposals for stone preservation, most of them designed to preserve the stone without changing its colour or appearance. Each new proposal has been put forward with claims that it has some advantage over its predecessors, but all experience so far has been disappointing. Some materials have caused discoloration; the use of some has been followed by scaling of the treated surfaces; some have had no noticeable effect at all.

When a stone-preservative is applied to a whole façade there is usually no way of judging whether it has a beneficial effect. The only way to arrive at a just assessment is to carry out trials in a manner that will allow direct comparison of treated and untreated surfaces of a similar kind, side by side. Where such trials have been made the results have been far from encouraging.

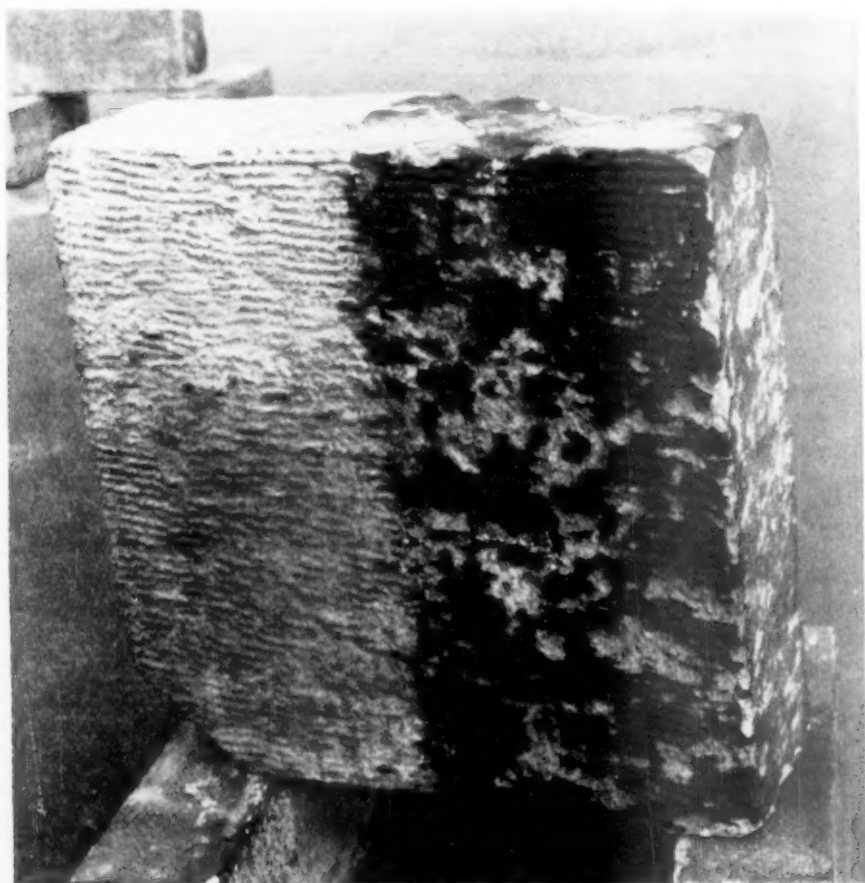


FIGURE 10. *Discoloration and scaling following treatment with wax*

In 1926 the Stone Preservation Committee of the Building Research Board organized a trial of that kind in London, using six representative methods of stone preservation on small piers of six different kinds of new stone and on a range of samples of weathered stone of different kinds collected from old buildings. Some of the treatments marred the appearance of the stone for a time. Apart from that, there has been nothing whatever to choose in weathering behaviour between treated and untreated stone of the same kind.

In another trial organized by the late Professor A. P. Laurie in 1925 on behalf of the (then) Office of Works, blocks of stone of five different kinds were treated over half their area, using four different treatments. Paraffin wax, melted into the surface by judicious heating with a blow lamp, prevented the erosion of limestones of good quality, but caused blistering and scaling in stone of poor quality within five years (Figure 10) and all the samples became badly discoloured. Blistering and scaling of the poorer kinds of stone also followed treatment with limewash or with a solution of magnesium silico-fluoride. Silicon ester had no apparent effect, good or bad.

In 1938 an experiment was organized to determine whether an elaborate treatment, using up to twenty applications of a solution containing zinc and magnesium silicofluorides, has any material effect on the weathering behaviour of Portland stone. Twelve large blocks in a building in London were selected, some of good quality, some of poor quality, and half the face of each block was treated. Silicofluoride solutions react with limestone, forming calcium fluoride and depositing silica, and the treatment hardened the face of the stone appreciably. Nevertheless there has been no sign of its having influenced the weathering behaviour.

At the same time, small blocks of Portland stone were treated in a similar manner, and other, similar blocks were treated with stone preservative liquids of other kinds. These were placed out of doors, first in London, and later, after having been stored during the war, at Garston (Hertfordshire). From time to time they have been brought indoors to be weighed after being allowed to dry slowly at the laboratory temperature until they reached constant weight. Each treatment increased the weight of the sample to some extent. In the initial stages of weathering the treated samples lost weight at a higher rate than the untreated samples, the treatments being less durable than the stone. Thereafter none of the treatments has shown to any advantage (Figure 11 overleaf). An apparent difference between the two sites in the rate of erosion of the stone is presumably indicative of the difference in the level of atmospheric pollution and is being checked by further observations.

Although these trials, and experience generally, have been so discouraging, no new proposal can be rejected out of hand. Conversely, no useful purpose is served by adopting a new process without question, in the hope that some good may accrue. Each must be considered on its merits. The latest additions to the range of stone-preservatives are those based on silicone resins. These have good water-repellent properties but it cannot be assumed that they will be more effective as stone preservatives than their predecessors. Judgment

must be reserved until comparative trials have been carried out over a sufficient length of time to warrant a considered conclusion.

Silicone preparations have also been suggested as a means of retarding the rate at which stone becomes dirty in a polluted atmosphere. Trials have been put in hand to determine to what extent they serve this purpose and how long they remain effective.

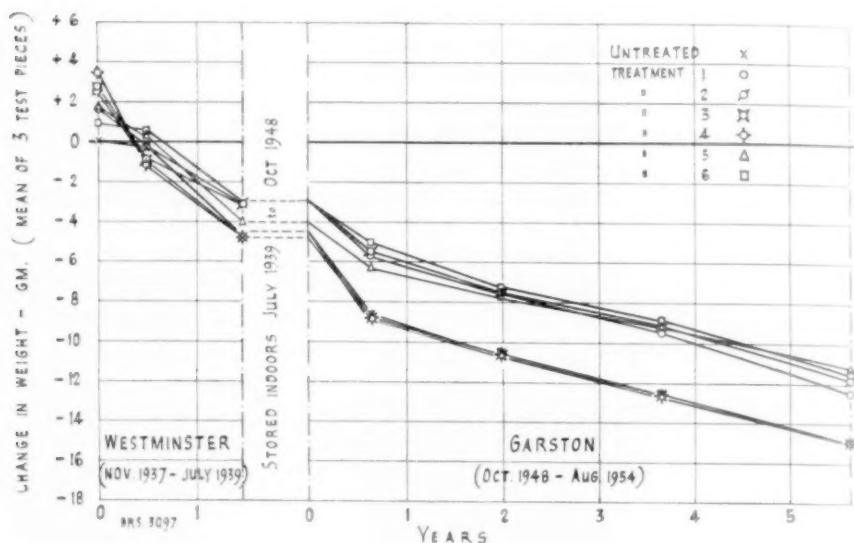


FIGURE 11. *No apparent effect of stone preservative treatments on the rate of erosion of Portland stone 2" x 2" x 4" prisms*

#### CLEANING

Some owners of commercial buildings take a pride in maintaining them in a clean condition and arrange to have them cleaned at suitable intervals. Where one sets an example, his neighbours often follow. Whether the same procedure should be adopted for old buildings that have acquired a familiar appearance in their dirty condition is a matter of opinion, but, thanks to those who have taken the initiative, there is less partiality for grime now than there was only a few years ago. Recent comments on the results have been more favourable than otherwise.

Cleaning reveals the colour and texture of the stone and uncovers detail in carvings and sculpture that may not have been seen for generations. Cleaning is beneficial to the stone in so far as it helps to remove the sulphates and other salts that contribute to cause decay. Cleaning will not improve upon the natural durability but it will enable the stone to give the best service of which it is capable. To ask if cleaning will prolong the life of a stone that normally lasts for centuries is rather an academic question.

Cleaning may be done with water or with steam. The circumstances in which the steam-cleaning process was introduced into London from Paris were described in the Society's *Journal* in 1887. It is unfortunate that those responsible at the time also imported the practice of using soda to facilitate the work. Thirty years ago the steam-cleaning process had fallen into disrepute because decay had occurred in buildings on which it had been used. The damaging effects, which were similar to those illustrated in Figure 7, were not caused by steam, but by soluble salts derived from the alkaline cleaning agents used. There have been no further complaints since the former practices were abandoned. Proprietary cleaning preparations commonly contain caustic soda or other alkaline ingredient. Some of the modern detergents contain sodium sulphate. To use any preparation of undisclosed composition is to court trouble. The risks are insidious because the harmful effects may not show themselves until some time after the work has been completed. Responsible cleaning firms now guarantee that no alkaline or other harmful cleaning agent will be used.

For cleaning limestone, a fine spray of water is as effective as steam, but either method is arduous if the operator works with nozzle in one hand and brush in the other. Much labour can be saved by allowing the water to play on the surface to soften and loosen the deposits before any attempt is made to brush them off. Suggestions to that effect arose from a chance observation, for it had been noticed that soot deposits could be removed quite easily from samples of weathered limestone that had been used for measurement of the water absorption. The (then) Office of Works took up the idea and used it successfully on a number of buildings in their care and the method has since been widely adopted.

To avoid causing inconvenience to the public it is now customary in London to do the work at night. No more water is needed than will suffice to keep the surface wet, but in practice the spray has to be heavy enough to avoid its being carried away by the wind. Penetration of water to the inner face of the wall is sometimes troublesome. Open joints need to be pointed beforehand and special care is needed around windows. The steam method uses less water and has an advantage in that respect.

If the deposits are sprayed for long enough they can be removed with no more than a light brushing. If the stone is sound stiff bristle, or even bronze, brushes can be used at an earlier stage and the removal of incrustations can be aided with wooden scrapers or by scouring with a piece of soft sandstone. How much aid of this kind can be permitted depends on how far the operatives employed can be trusted to proceed with appropriate discretion.

A freshly-cleaned building soon becomes dirty again in a heavily-polluted atmosphere. Regular hosing with water will help to maintain a clean appearance. At the Goldsmiths' Hall the practice has been to wash down with the fire hoses at each six-monthly inspection of the appliances. The façades of many London fire stations show how clean stone can be kept by regular washing.

Soot-blackened sandstone and granite are prone to be exceedingly difficult to clean. Neither steam nor water makes much impression. Firms that operate on buildings of that sort have methods for dealing with them and are prepared

to demonstrate by reference to buildings they have cleaned over a period of years that their methods can be used without harmful effect. They too will guarantee that no alkaline detergents (which can be as harmful to sandstone as to limestone) will be used.

Scouring with power-driven tools or redressing the surface by hand yields good results in appropriate circumstances and in competent hands, provided always that the underlying stone is in a sound state. Although it is commonly said to be fatal to remove the weathered face from a building stone, enquiries have failed to find evidence to substantiate that belief.

#### RESTORATION

There is a diversity of opinion on whether new stone replacements should match the old stone, or be clearly distinguishable from it, and an equal diversity on whether it is legitimate to adopt the method of plastic repair, cutting out the decayed surfaces and restoring in a mortar of appropriate composition. Much depends on the circumstances and the decisions must rest with those responsible for the maintenance of the buildings concerned and their architectural advisers. Where new stone is used, its colour, texture, compatibility with the existing stone, and its quality are among the considerations that govern its choice.

Under competent supervision, good work can be done by the method of plastic repair, if the operatives have the necessary skill and the right flair for the work. It is important to recognize that the finished texture of the surface and the treatment of the joints can make or mar the effect and that the repairs must always be substantially executed: it is useless to cover an eroded surface with a thin rendering of mortar. Heavy plastic repairs need to be securely dowelled to the stone, which must itself be strong enough to support them. The colour and appearance can be matched with the stone initially but it is largely a matter of chance whether plastic repairs remain inconspicuous. Subsequent changes in tint or differences in weathering behaviour between stone and patch may betray the method of repair all too noticeably, though there are cases where repairs executed many years ago are still scarcely distinguishable.

In some circumstances simple redressing of the stone to an appropriate depth to expose a new sound face merits consideration, if the architectural problem of dealing with window openings and the like can be met. The example illustrated in Figure 12, where this procedure was adopted as much as 35 years ago, seems to substantiate the view that there is no technical objection to this procedure, despite the current and long-standing belief to the contrary. The new face is still in good condition and the stone, which is not of high quality and was formerly in a state of dilapidation, may be considered to have been given a new lease of life.

#### THE TESTING OF BUILDING STONE

In selecting stone for new building or for work of restoration, the colour, texture, cost, size of block, working qualities and compatibility with neighbouring materials call for attention. For exterior work, durability is a primary requirement.

Tests are more often required to give assurance that the stone will be durable in the situation in which it is to be used than to provide engineering data on its strength or elasticity. Knowledge of the transverse strength is required for calculating the appropriate dimensions of lintels (British Standard 1240). The compressive strength (although the property most commonly reported in trade literature) is of no immediate significance. Even the weakest of building stone will carry the load normally imposed on it, and the strongest may fail if subjected to high concentrations of stress through uneven bedding of the blocks or as a result of settlement.

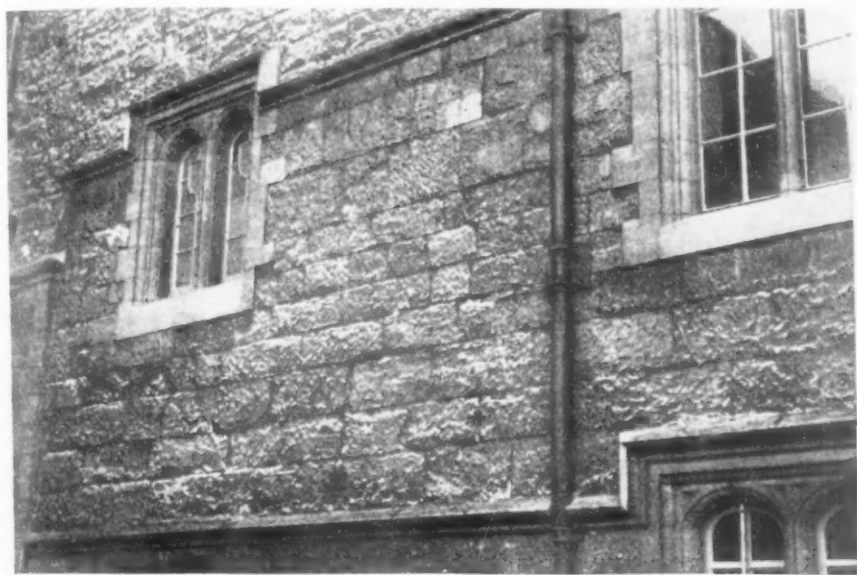


FIGURE 12. *Redressed limestone (of poor quality)  
still in good condition after about 35 years*

Inspection of buildings in which a stone has been used will give a more reliable impression of its weathering characteristics than any laboratory test, but the prospective user may still need assurance that the stone supplied is of comparable quality, or he may wish to compare the products from different quarries in the area or to know how much the quality of the stone varies in different parts of the quarry. The tests used must obviously be based on the study of an adequate range of samples known to be of good or poor weathering quality to ensure that the tests are relevant to their purpose and to give confidence in their interpretation.

Accelerated weathering tests designed to reproduce within a few days or weeks the effects that normally occur in the course of years, are beset with uncertainties. The better alternative is to study the physical and chemical properties, aiming to ascertain which of these will serve to differentiate the more durable from the less durable stone.

## FREEZING TESTS

Experience with laboratory freezing tests illustrates the difficulties attaching to the use of accelerated weathering tests. Though it might seem that nothing could be simpler than to freeze a saturated sample in the laboratory to decide whether a building stone will be frost-resistant or otherwise, it is proving more than difficult to reproduce the effects of natural freezing. We are still without a reliable form of freezing test for stone, brick or concrete, despite the large volume of work that has been done, using a variety of procedures and various methods of evaluating the extent of the damage caused.

Experience elsewhere has been no more satisfactory. A recent enquiry addressed to thirty laboratories in Europe, Canada and the United States, asking about their experience with freezing tests on concrete, showed that no laboratory had very much confidence in the results. Again, two Continental laboratories, at different times, have been misled by their laboratory tests into reporting adversely on the frost-resistance of Portland stone. There can be no question that the fault lay in the test, for there are innumerable buildings in this country and many thousands of headstones in the war cemeteries on the Continent to testify to the good qualities of Portland stone in that respect.

Much more useful results can be obtained by relying on natural freezing, accentuating the conditions to the extent of keeping the samples continuously

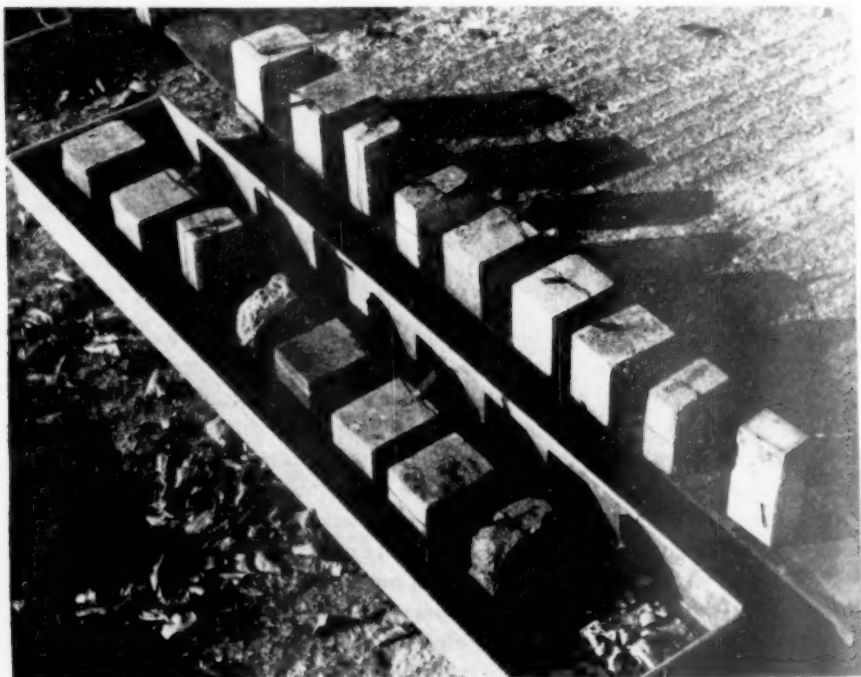


FIGURE 13. *Natural freezing (tray) test*

in a highly-saturated condition to take full advantage of every frost. This is done quite simply by allowing the samples to stand in trays in a shallow depth of water (Figure 13). When exposed in this way, samples of poor frost-resistance fail in a reasonably short time, while those of high frost-resistance remain unaffected for winter after winter. The results, on the whole, are in good agreement with practical experience in buildings. A striking example is afforded by a range of nine varieties of Bath stone, of which, when they were all available, only two were recommended by the suppliers, in the light of their experience, as being suitable for copings, sills and other exposed features. In the test, these two have survived for more than twenty winters; the others failed within the first few winters. Some stone of poor frost resistance has failed within a few days in frosty weather. The test errs perhaps towards severity, in the sense that all samples of a poor stone usually fail quite quickly, whereas in practice it may be only a block here and there that will fail in a coping. Filling the tray with sand and draining off the surplus water appears not to moderate the effects to any large extent, but there has not yet been enough experience to judge whether this alternative has any advantages. The tray test has the merit of simplicity. While it may take two or three winters to decide whether a stone can be considered suitable for use in places where there is risk of its being damaged by frost, it is obviously better to await the results with patience than to use a laboratory test that may lead to an entirely wrong conclusion.

Frost-resistance is dependent on the physical properties of the stone. What defines the relationship is still uncertain, but empirical observations provide a means of estimating the frost-resistance of stone from a knowledge of certain of its properties. When water at the freezing point changes into ice the volume increases by about ten per cent, and the stresses induced in the frozen material may depend in some measure on how much room there is to accommodate this expansion. With this in mind, Hirschwald in Germany, at the beginning of the century, introduced the conception of the saturation coefficient, which is a measure of the extent to which the pores become filled when a sample is immersed in water for a limited time. The saturation coefficient is usually determined as the ratio between the volume absorbed by immersing the sample in water for 24 hours and the total volume of the pores, the latter being conveniently measured by saturation *in vacuo*. For building stones of different kinds the values of the saturation coefficient range from about 0.50 to about 0.95. The saturation coefficient is not dependent upon a fortuitous trapping of air in the pores. It is a characteristic property determined by the pore structure. The figures are reproducible, and they are not greatly influenced by the size of the sample. Materials with coarse, interconnecting pores or with a proportion of such pores give relatively low values. Those without many large pores give higher values. If the water is absorbed slowly from one face a higher degree of saturation is reached, but much the same relative differences appear among materials of different structure. The physical explanation of the differences in saturation coefficient is not known precisely, but it would seem to be related to the hysteresis observed in curves relating the water content with the capillary potential (or

suction) of the material. Haines, at Rothamsted, studying the way in which water is held in a mass of glass beads, showed that, when the beads were wetted, zero suction corresponded to a state in which the interstices were not completely filled.

Hirschwald, to be on the safe side, adopted a limiting value of 0.80 as the criterion of frost-resistance, but found it necessary to take account also of the wet/dry ratio of the strength of the stone to assess the frost resistance by what he termed the 'theoretical' method.

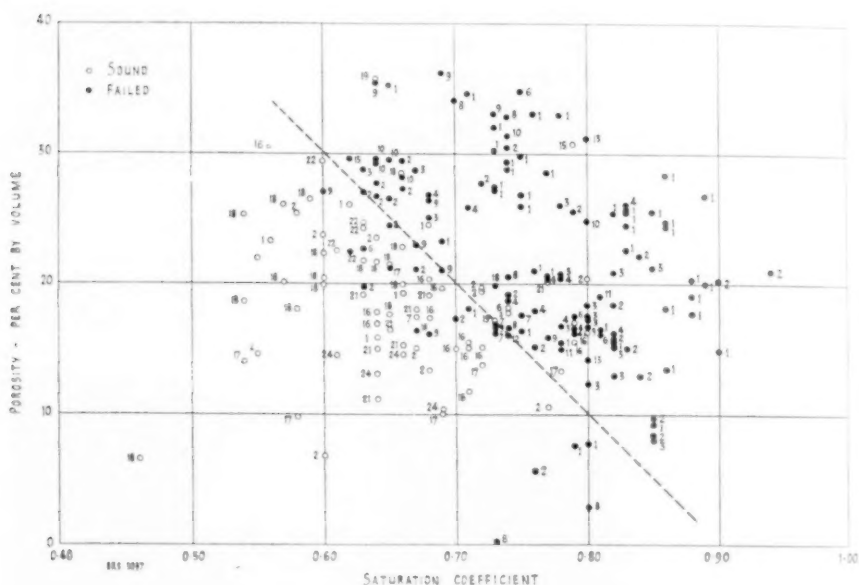


FIGURE 14. *Tray exposure test, limestone.*  
*Numbers indicate period of exposure in years*

Reference to the results of the 'tray' exposure tests shows that it is not necessary to undertake strength tests; porosity measurements will serve. This has the advantage that porosity is more easily measured, and can be measured on the sample under test. It can be seen that among limestones (Figure 14) the saturation coefficient alone is not a good criterion of frost-resistance, but that reasonable deductions might be made by taking both the saturation coefficient and the porosity into account. The higher the porosity the lower is the safe limit for the saturation coefficient. Judgment of frost resistance on the basis of these empirical relationships would not be infallible but would be more reliable than any artificial freezing test yet devised. There is no obvious reason why the porosity should have this apparent influence unless it be that the porosity reflects the strength. Investigations in France have shown that among limestones there is a broad relationship between porosity and strength.

Sandstones, as a class, are more resistant to frost than limestones. Very few of the many samples examined by means of the tray test have been damaged (Figure 15). Judged by the criteria of porosity and saturation coefficient they fall into the appropriate area of the chart. In sandstones the interstices between the non-porous sand grains are relatively coarse and the values of the saturation coefficient are correspondingly low.

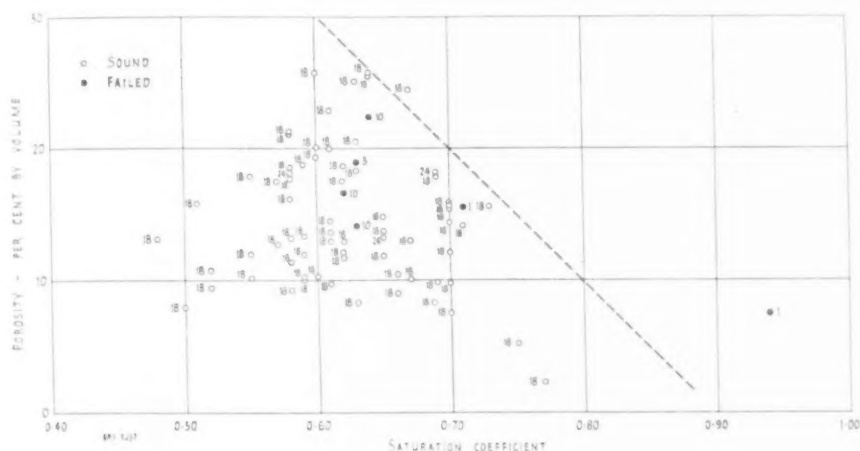


FIGURE 15. Tray exposure test, sandstone. Numbers indicate period of exposure in years. The dotted line is transferred from Figure 14

The heaving of soils in frost is attributed to the formation and growth of ice lenses beneath the surface, their growth being brought about by the migration of water from the lower, unfrozen levels to the freezing zone. Frost damage in buildings may possibly be caused in a similar manner. There are sometimes indications of a mechanism of that kind in the 'tray' exposure test. Moreover fracture (Figure 16 overleaf), reminiscent of the kind of damage that occurs in buildings, has been induced in a sample frozen slowly from one face and with a free supply of water from the unfrozen face, though this did not occur until extrusion of ice at the sides of the sample was prevented by waxing the surfaces.

If frost damage in buildings is brought about in some such way as this, the conception of the saturation coefficient assumes a different significance. The numerical value need not then be regarded as a measure of the space available to accommodate the larger volume of the ice, but as being indicative of the kind of pore-structure that favours or does not favour the migration of water to the growing ice crystals. One other difficulty disappears. Systematic measurements of the moisture content of stone copings have shown that they reach and are maintained at a high level of saturation during the winter months, higher where the stone has a high saturation coefficient, but in any event well above the ninety per cent level that would leave room for expansion within the pores.



FIGURE 16. *Fracture induced by slow freezing from one face*

The work in question is still going on. These comments are somewhat speculative, but it is evident that the mechanism of frost damage is not as simple as it might appear, and it is perhaps not to be wondered at that laboratory freezing tests have given disappointing and misleading results.

#### CRYSTALLIZATION TESTS

Crystallization tests provide another means of assessing the relative qualities of different varieties of stone. Such tests originated in 1828 with Brard in France who allowed sodium-sulphate to crystallize within the pores and proposed to judge the frost resistance from the degree of disintegration that resulted. Since

then, various modifications of his procedure and various other salts have been proposed and tried. Our experience is that 15 repetitions of a cycle in which samples are immersed at a constant temperature of about 20°C. in a 14 per cent solution of sodium sulphate (10 H<sub>2</sub>O) for two hours, and are then dried over night in an oven, gives relative results that are broadly in accord with observations of relative behaviour in practice. The use of a more dilute solution can be helpful on occasion. Stone of poor quality suffers more disintegration than stone of good quality. The test also reveals the presence of soft beds in stone and tends to reproduce in some measure the type of decay to which the stone is susceptible. Among limestones we find a similar sort of relationship between saturation coefficient, porosity and degree of disintegration as that described in connexion with the effects of frost. To that extent, Brard's proposal to use the test as a substitute for a freezing test may appear to be justified, but this deduction does not apply to sandstones; few of these are affected by frost, but many of them are susceptible to the effects of salt crystallization.

## PORE-SIZE DISTRIBUTION AND THE WEATHERING QUALITIES OF LIMESTONE

The durability of a limestone depends on its structure. Differences in structure can be observed under the microscope and the values of the porosity and saturation coefficient are somewhat crude measures of these differences. It is necessary to differentiate the structure more precisely to determine what features have a predominant influence on the weathering quality. The methods that are used for the study of the moisture relationships in soils lend themselves to that purpose. These methods characterize the pore-structure in terms of the adsorption and surface-tension forces to which water is subjected in the pores. In any system of interconnected pores these forces are related to the sizes of the pores and vary with change in the moisture content.

The capillary potential, pressure deficiency, or 'suction', of a porous body increases with decrease in the water content. When the pores are completely filled with water the air/water interface at the surface is flat; the pressure is the same in the water as in the air and the suction is zero. If the water content is progressively reduced, the air/water interface becomes increasingly curved, because the water retreats into smaller and smaller pores or into narrower necks or channels, distributing itself at each stage until, in an equilibrium condition, the curvature of the interface is at a minimum and is everywhere the same. At the curved interface the pressure in the water is less than the pressure in the air on the other side of the boundary, the pressure deficiency being inversely proportional to the radius of curvature. Hence, there is a continuous relationship between the moisture content and the pressure deficiency which is dependent on the sizes and shapes of the pores and is different for each material. The pressure deficiency is conveniently expressed in terms of Schofield's  $pF$  scale,  $pF$  being the common logarithm of the height in centimetres of the water column that an equivalent suction would support against gravity.

Using direct suction, centrifuge and vapour pressure methods, the relationship between moisture content and pressure deficiency can be determined for each material over the range of moisture content from the saturated state to the (almost) dry condition. From the curves so obtained, histograms can be prepared which are indicative of the pore-size distribution. The differences revealed can then be related to what is known of the relative qualities of the samples under examination.

The relationship between pressure deficiency and moisture content is not unique; the water content corresponding to a given pressure deficiency is less if equilibrium is approached from a drier condition than if approached in the reverse direction. This hysteresis may, as has been mentioned, have some bearing on the significance of the saturation coefficient. For the analysis of pore structure the measurements must obviously start from the state in which the pores are completely filled with water.

Portland stone has been more thoroughly examined by these methods than other varieties of limestone. The same methods can be applied to the analysis of the pore structure of sandstones, but with these the durability is related to the

chemical composition as well as to the structure. Portland stone enjoys a very high reputation for durability, but there are variations in quality and occasional blocks fail to give the service expected of them. A notable example can be seen in the Epstein figures on Rhodesia House, in the Strand, formerly the headquarters of the British Medical Association. The figures, which date from 1908, are now sadly decayed. The quality of Portland stone cannot be judged by inspection, and laboratory methods for doing so had not been devised at that time, so it may be supposed that the deficiencies in the quality of the stone were not suspected and that the blocks were chosen for their even texture and good working qualities. The stone used has the structure of the poorer stone described in the next paragraph, but no sufficient samples have been available for further examination.

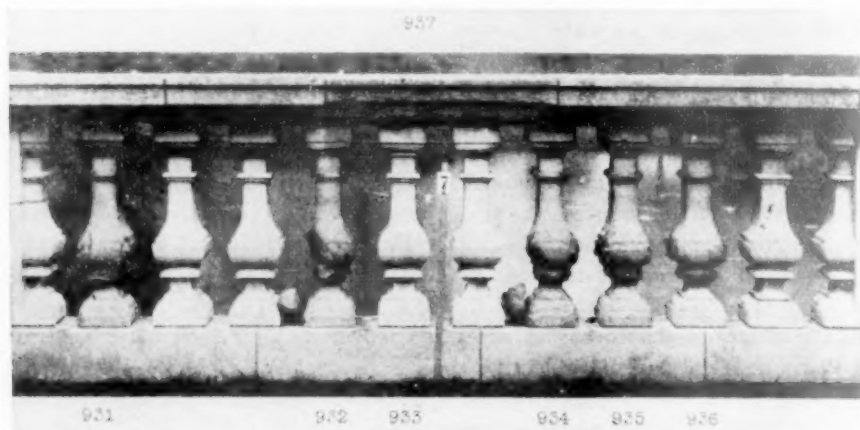
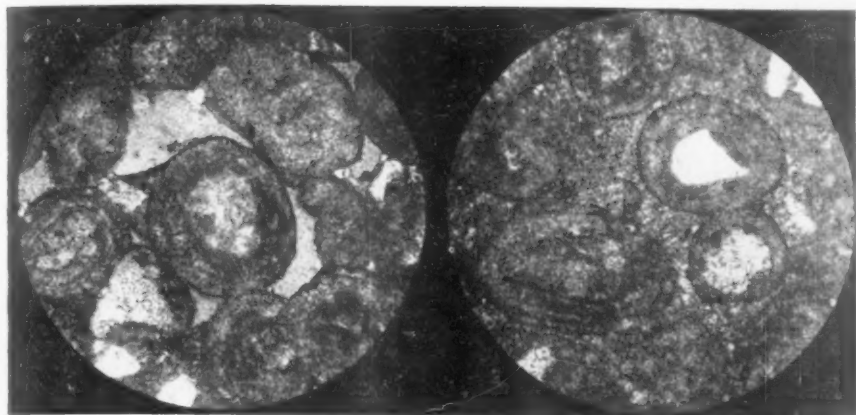


FIGURE 17. *Portland stone of variable quality: see Table 1.*  
(Portland stone of the poor quality illustrated is of rare occurrence)

Another example, dating from about 1910, is illustrated in Figure 17. Portland stone of the less durable kind has a different structure from the general run, in that the spaces between the oolitic grains, which normally form large, interconnected pores (Figure 18a), are filled with a microporous matrix (Figure 18b). The curves relating pressure deficiency and moisture content are correspondingly different, and the difference can be simply expressed in terms of macro- and microporosity if we adopt an empirical distinction and consider microporosity to be that proportion of the total volume of the stone represented by pores that will hold water against a suction that would support a 600 centimetre column of water against gravity. This corresponds theoretically to the suction exerted in a circular capillary having a diameter of 0.005 millimetres.

Table 1 shows that the good and poor samples are indistinguishable in porosity, but can be distinguished by reference to the microporosity, the saturation

FIGURE 18. *Portland stone*(a) *good quality*(b) *poor quality*

coefficient, and resistance to the crystallization test. In chemical composition there is no significant difference between them.

TABLE I. THE PROPERTIES OF PORTLAND STONE ILLUSTRATED IN FIGURE 17

<i>Lab. No.</i>	<i>Condition in balustrade</i>	<i>Porosity per cent</i>	<i>Microporosity per cent</i>	<i>Saturation coefficient</i>	<i>Loss in crystallization test, per cent</i>
931	decayed	16.0	15.4	0.79	38.8
932	"	16.2	15.6	0.78	29.1
933	sound	15.4	9.2	0.64	0.1
934	decayed	16.4	15.8	0.97	35.6
935	"	16.1	15.5	0.80	25.0
936	"	15.9	15.2	0.79	20.0
937	"	16.2	15.8	0.80	32.6

Other tests have shown that Portland stone of the highest quality may have little more than half the compressive strength of that of the poorer kind. High strength gives no assurance of durability.

These methods of examination have been applied to a range of samples of Portland stone collected from buildings and the results have been used as a yardstick to assess the quality of several hundreds of samples from the quarries. Among these samples there is a broad relationship between the microporosity

and the saturation coefficient. Both properties vary over an appreciable range and there is a corresponding variation in their resistance of the crystallization test. *So far, no stone of the very poor kind illustrated has been found among the quarry samples.*

Among the Bath stones, again, the more durable kinds are those that contain a proportion of large pores in their structure, and these, too, can be differentiated by reference to measurements of microporosity, saturation coefficient and resistance to the crystallization test.

With Clipsham stone, on the other hand, measurements of pore-size distribution have not yet given results of any practical value. However, the quality can be assessed by reference to the saturation coefficient, and to the effects of the crystallization test and the natural freezing test. Unlike Portland stone, Clipsham stone can be selected with reasonable confidence by inspection, and experienced users have made a practice of choosing the stone in the quarry for themselves. Laboratory tests can be used as a check and to resolve any difficulties.

The laboratory methods described have been used to assist in the choice and selection of stone for the restoration of the Houses of Parliament, which has been going on under the direction of the Ministry of Works since about 1928, has cost over £1,000,000, and is now nearing completion. The Royal Commission appointed in 1839 to choose the stone for the building recommended the use of a magnesian limestone, Bolsover Moor stone, but the quarries were unable to supply enough of it and another magnesian limestone, Anston stone, was used instead. The building was completed in 1851. In 1861 another Royal Commission was appointed to enquire why the stone had begun to decay and what should be done to prevent it. The superficial decay with which they were concerned has proved to be of comparatively little consequence, but the building subsequently became dangerous when pieces began to fall from the decorative features because of the opening of concealed planes of weakness (vents) in the stone, and because extensive deterioration had occurred in blocks that had been face-bedded. Hand-picking was resorted to for a time, but eventually it became imperative to undertake repairs. The first proposal, that a Derbyshire sandstone should be used, was abandoned, because it was realized that a sandstone would become quite black in the London atmosphere and also because this sandstone would not be compatible with Anston stone. Eventually Clipsham stone, a shelly limestone from Rutland, was chosen as being the only limestone available in quantity that would meet the requirements in respect of colour and durability. Ketton stone has also been used to a limited extent.

Clipsham stone is derived from a shallow-water deposit; the beds are irregular and the stone is subject to wide variations in quality. Special care has had to be taken in selecting it. An inspector has been employed in the quarries and laboratory tests have been made from time to time, whenever necessary, the whole object being to secure stone of the best available quality. All those concerned have done their best to ensure that the result will be satisfactory, and it is to be hoped that our successors will have no reason to criticize the work.

## CHEMICAL TESTS

Chemical analysis affords no help in assessing the quality of a limestone. Skin formation, accompanied by blistering and scaling of the surfaces, can be induced under laboratory conditions by exposing samples to moist air containing sulphur dioxide, but methods of that kind have shown no promise of being useful in distinguishing between limestones of good and poor quality. Limestones are better dealt with by the physical methods that have been described.

Among sandstones, the presence of any large proportion of carbonate is usually indicative of poor durability (though there are some anomalies that await further study). It is not necessary to carry out a full chemical analysis. A simple acid-immersion test will suffice. Other properties have also to be taken into consideration. As has been mentioned, sandstones as a class are highly resistant to frost. They vary in resistance to salt-contamination and their behaviour in the crystallization test often gives useful indications of their probable weathering behaviour.

Some roofing slates contain carbonates and are liable to deteriorate in polluted atmospheres. Some contain carbonates together with compounds of sulphur which oxidize on exposure to the weather, producing sulphuric acid, which reacts with the carbonates present: slates of that kind deteriorate even in districts where the level of pollution by sulphur fumes is very low. Appropriate tests have been incorporated in the British Standard for Roofing Slates (B.S. 680).

There are only a few Continental quarries that produce roofing slates that bear comparison with those produced in the United Kingdom. Some varieties of imported slate contain a very high proportion of carbonate and are quickly reduced to mud when submitted to the acid-immersion test of the British Standard. No British slate is known that breaks down in this manner. Such slates cannot be commended, even for use in country districts.

*Acknowledgment*

This and the foregoing lecture were delivered by permission of the Director of Building Research. The author wishes also to express his thanks to those of his past and present colleagues at the Building Research Station who have contributed in no small measure to the work described. He is also indebted to officers of the Ministry of Works and others for helpful information and for the provision of weathered samples for examination.

## III. THE STONE MASON'S CRAFT

by

W. F. HASLOP, O.B.E.

*Monday, 16th May, 1955*

The two previous lectures on the subject of 'Stone in Architecture', were concerned with 'Stone as a Building Material' and 'The Weathering, Preservation and Restoration of Stone Buildings'. I was not able to hear those lectures and, as it has been my business over many years to deal at first hand with this kind of work, I would ask the previous lecturer to forgive me if I encroach in any way on his ground.

No one can deny that, for pure building, stone is the most important of all materials, and is perhaps the earliest material used for making a permanent structure. This subject, 'The Stone Mason's Craft' is so vast that in a short lecture it is only possible to give a general outline. I would add to the title of this lecture, 'The Mason's Mind and Method', for though he never was a scientist as we know science to-day he always had, and still has, a considerable scientific bent. For the want of a better name, I call this 'Lever' or 'Leonardo' science, that is, the kind of skill which enabled him to do his work without vast paper calculations. The buildings which still stand after many centuries prove the truth of this contention.

A recent lecturer here described Eric Gill as a stone mason, and on that ground I have brought sculpture into the picture. Being, amongst other things, a sculptor myself I can see how much the two should work together. In these days, the two branches of stone cutting, or at least the design for it, are not so happily united, and I do not know which is worse: a sculptor's architecture or an architect's sculpture. A notable exception is Sir Ninian Comper; a figure drawn by him looks like that drawing when carved. Michelangelo we know did both. He carved figures with his own hand and designed great works of architecture; and other great masters of the past have shown that versatile quality.

Apart from design, the fundamental factors in the stone mason's craft are 'weight', which we know as gravity; and 'bond', the method of so placing the stones that they tie each other together without artificial means. If these two factors are properly used, a building is not likely to fall even if the stones are laid dry. That is pure building.

For a long time I have maintained, and the real mason has always unconsciously known, that the keystone is the least important member in an arch. Essential though it is, it does less work and carries less weight than the others. To illustrate this point, if a piece of wood were inserted across the position of the keystone it would, within certain limits, do the same job. I have here a model of an arch made of separate pieces of wood placed together dry. Now by pulling the keystone out rapidly you will see that the arch just falls together at the top and does not

FIGURE 1. *Typical Roman lintel construction*

fall down. We often see arches where the keystone has dropped, thus bearing out the point of my assertion. (*The lecturer demonstrated his point by use of a model.*)

The earliest stone buildings were simply walls built of blocks of stone placed generally in courses, that is, in regular layers, with lintels of stone across the openings. This being so, it can be seen that the width of any opening was controlled by the length and strength of the stone available. Columns were used to obtain greater, though not uninterrupted, openings and, as time went on, mullions were used on the same principle to enable the vast gothic windows to be formed, though we must not forget the value of the arch in the latter. Figure 1 shows a typical Roman building of the lintel type, in which it is easy to see that the whole structure is self-supporting.

Sometimes it was not possible to find stones long enough to span the width of the opening desired. In such cases, lintels of lesser length than the actual opening were used, jointed to what was virtually a continuation of the lintel by means of a radiating joint with a set off about half way up to form a seating, and so prevent spread. It is obvious in such construction that the continuation of the lintel must act as a corbel with considerable weight—tail weight as the mason calls it—above, to form a cantilever. Stonehenge is a supreme example of the lintel used in its simplest form.

In Figure 1 the building looks, and is, safe though we must concede that it is necessary in modern times to have much wider openings into buildings. But what false masonry is the present practice of hanging up to steel thin stone architraves or lintels many times longer than solid or corbelled lintels could possibly span. Why use stone for the purpose at all? The Italian practice of covering their brick buildings with thin panels of fine marble is a reasonable excuse. The concrete and steel Waterloo Bridge by Sir Giles Scott is, at least above the arches, veneered in Portland stone, but I believe the arches themselves are of exposed concrete and therefore the whole structure does look honest.

Figure 2 shows the Roman theatre at Fiesole, a perfect example of the stone mason's craft in its purest form. Great stones were selected for the seats, and smaller ones for the wall and arch. After 2,000 years the wall is intact and there is no doubt that this is due to the proper use of bonding stones penetrating deeply into the thickness of the wall. The fascinating texture of the wall face here is the result of the mason's intuition in using stones of dimensions which make use of the maximum strength of the stone. Longer and thinner stones would, and do, crack under great weight, while shorter upright stones would not give enough lap or bond across those above and below to guarantee permanence. This kind of wall-face texture has persisted throughout the ages and looks so natural. It can be seen all over England, in the walls of great castles and churches and, in stone districts, in the smallest farm buildings and cottages.



FIGURE 2. *Roman theatre at Fiesole*

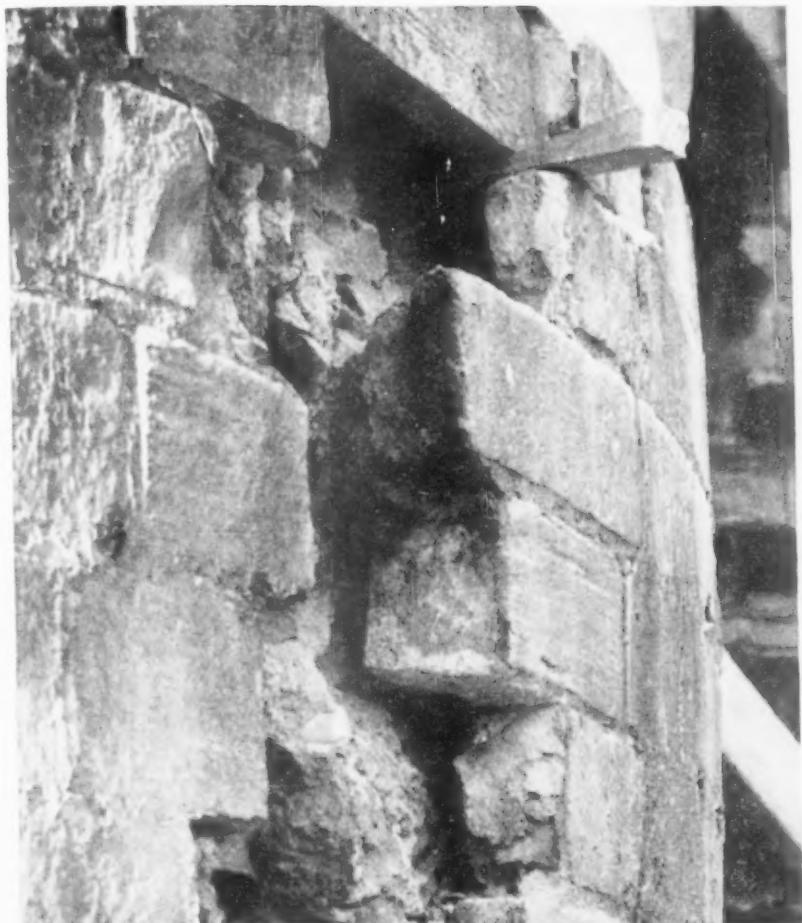


FIGURE 3. *Norwich Cathedral, St. Luke's Chapel*

Norwich Cathedral is a typical example but Figure 3, of St. Luke's Chapel, reveals that the lack of long bond stones going into the thickness of the wall has resulted in disaster. Norman buildings in England had very thick walls formed of a core of flint or rough stone bedded in lime of a fine quality; the latter as good to-day as when it was first put there. It would be a good thing if we to-day could concentrate more on the quality of lime which, with its slightly flexible property, has contributed as much as anything towards the permanence of our pure stone buildings. Figure 3 shows a bulge on the wall face which, if allowed to get beyond a certain point, would become really dangerous. In a case like this, while the bulge is only slight, the pressure of the human hand would be sufficient to save the wall, and it is quite easy to see that bond stones going into the thickness of the wall act in the same, but in a permanent, way.

In this circular building of St. Luke's Chapel bronze chains have been inserted behind two courses round the building, with long bond stones above and below them. Thus the value of weight in its safe direction has been retained.

Whilst on the subject of circular buildings, the Leaning Tower of Pisa, shown in Figure 4, is worthy of special note. It is true that the tower leans at an apparently dangerous angle, but a close inspection clearly gives the reason for its survival. It is so well bonded with solid masonry that many courses virtually become chains going right round the building, and while there is no further settlement underground there would not appear to be any real danger.

It is notable that the early builders relied on the thickness of the walls rather than spread foundations. So long as the subsoil could not spread out the compressed subsoil below adequately carried the weight. It has sometimes been advisable to construct retaining walls to contain and maintain the compressed subsoil under the walls, rather than risk underpinning with its resultant slight initial settlement and slight fractures. A small fracture through stone is as serious

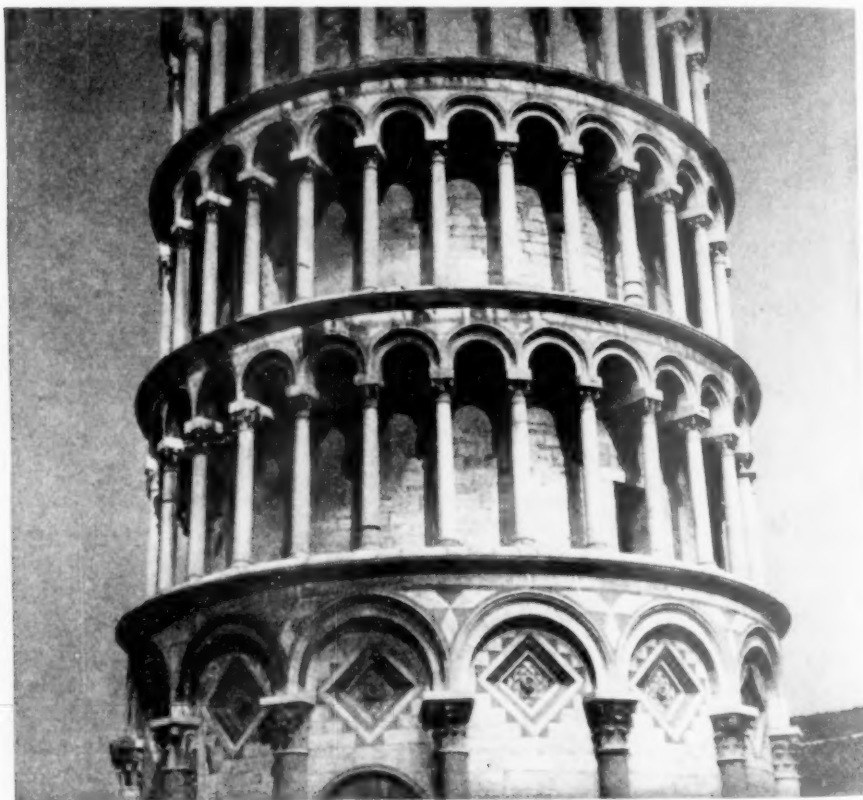


FIGURE 4. *The leaning tower of Pisa*

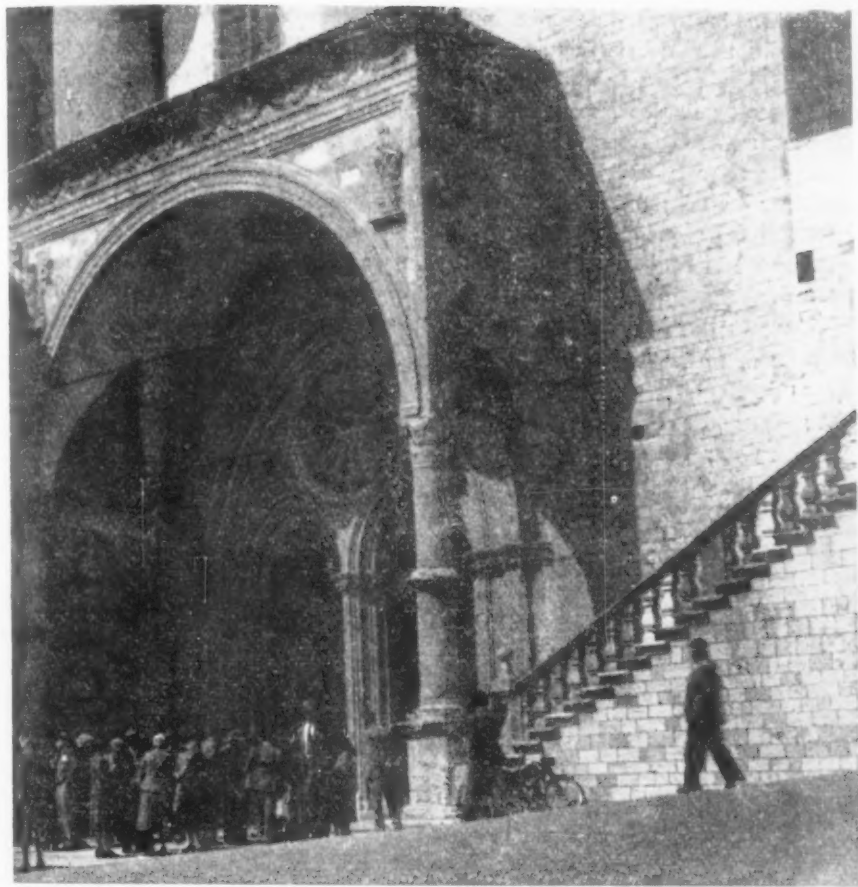


FIGURE 5. *Assisi Cathedral, porch*

as a large one because grit, filtering down due to slight vibration, acts with a ratchet-like motion, and the crack cannot close up again.

I have mentioned the very slight pressure needed to keep stone in its safe gravity position. This applies also to an arch which has no abutment. Figure 5, the porch at Assisi Cathedral, shows how the outward thrust is held in by thin tie rods. This illustration gives another example of a beautifully textured ashlar wall face.

Structurally, the mason's first consideration is the jointing and bonding of his stones. Most kinds of stones have a fairly definite 'bed', that is to say, geologically formed layers. This bed is very apparent in some stones, slate for instance, but in others it is so faint that in quarrying the stone lines are marked vertically on the sides of the blocks to show which is the natural bed. For plain wall masonry it is obvious that the stones should be laid on their natural bed

so that the layers are horizontal and therefore able to withstand great weight. An additional value is that there are no exposed layers to flake off, a defect which would occur if the natural bed were in the same plane as the wall face. The mason calls this face bedding. Apart from damage which could be caused by pressure on the front edge, there is the risk, because stone is porous, of frost separating the layers. In an arch, the natural bed is arranged to follow the radiating joints as near as may be, thus keeping the pressure directly on to the natural bed.

Long slender mullions are generally placed to what the mason calls edge bedded, that is to say the natural bed is parallel to the sides of the mullion. The reasons for this are first, that with many building stones it is not possible to find stones high enough in their natural bed to avoid the weakness which would



FIGURE 6. *Ely Cathedral, Lady Chapel*

result from many small pieces of stone piled above each other. Imagine, for instance, a tall slender mullion built of bricks. It would buckle sideways. This is done sometimes, but the strength of the mullion then depends upon saddle-bars and is not pure masonry. Secondly, having decided that natural bed is out of the question, the mason sees at once that face-bedded stone would expose the very narrow front edge to much more danger from pressure and deterioration from weather. Mullions of large sectional plan are built with stones on their natural bed; such a mullion can be seen in Figure 6.

The mason does all he can to arrange his horizontal joints, known to him as beds, at right angles to the direction of the pressure on them, but he also has to consider the detail to be worked on the stone. Figure 6 shows a buttress, on the Lady Chapel at Ely Cathedral, which is a border-line case.

For the sloping-string course, here the mason naturally gave way to keeping the beds horizontal, for the sake of the main structure, at the risk of the feather edge caused where this horizontal bed crosses the string; it is not so on the mould weathering on the gablet where he has kept to the safe square bed. To have got a square abutment on the sloping string would have entailed much more labour and stone, and the good mason was always very economical in the use of his material and the method of using it. Stone very high on bed is always difficult to find in most quarries. The solid sound strata extends for a certain distance down before reaching a weak bed or actual break. For this reason it is not always possible to make, for instance, a very high cross or a tall figure standing on its natural bed. On the other hand, if the stone is placed with a direct vertical bed it is subject to weather deterioration. An intermediate course is therefore sometimes taken. A stone of the highest dimensions obtainable is selected, and the object which it is to make is cut slightly diagonally across it. The result is

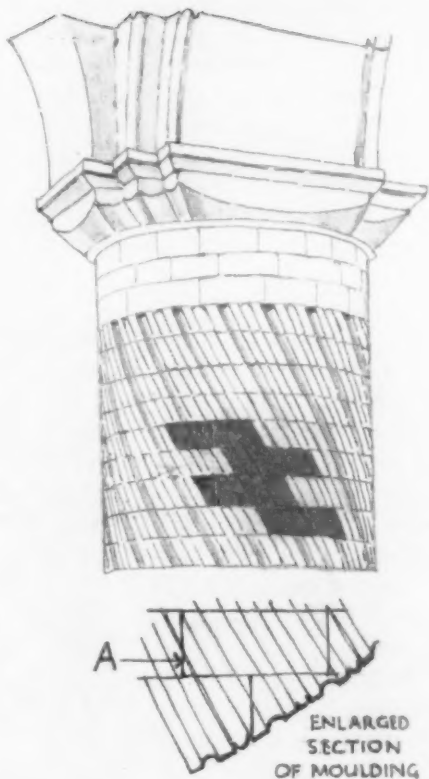


FIGURE 7. *Norwich Cathedral, nave pier*

that there is no direct bed running vertically, and therefore no face-bed to flake off, and although the stone is not quite as strong as a vertical bed, it is stronger than a natural bedded stone, particularly in the case of a tall slender shaft.

Pinnacles are almost always placed on their natural bed. They are generally in low stones, the natural bed giving a kind of reinforcement to the projecting crockets. The many horizontal joints are hidden by the breaks formed by the crockets, and the stones are held against wind pressure by dowels. Nowadays we use bronze dowels, sometimes in continuous lengths. The great pinnacles on King's College Chapel originally had wooden dowels, but the sectional plan of them is so great that the dowels served little purpose except that of positioning the stones above each other, with the possible exception of those in thin neck below the finial.

The great twisted column in the nave of Norwich Cathedral (Figure 7) is a very interesting example of jointing. The beds here are naturally placed horizontally, but the joints follow the lines of the twist design. This column alone shows what thought the mason put into his work. Each stone is two unit patterns long and the joints of one course are arranged to meet the centre of those stones immediately above and below, as I have indicated by the blacked portion in the drawing. A feather edge naturally occurs at the top left and bottom right corners of each stone but this is a lesser evil than horizontal joints, marked A on the drawing, which, though they might have been structurally sounder, would have given feather edges through the pattern itself, apart from disturbing the design.

The capital in Figure 7 serves to show what the mason calls tail weight. Generally a capital is in one piece of stone and the overhanging arch which it supports on one side is compensated, or tail weighted, by the arch on the opposite side. In the case of a corbel, as we might assume one section of this capital to be, the stone is taken well into the masonry and the weight of the masonry above creates a safe cantilever. Corbels are made with a greater weight on the wall than the overhanging part to facilitate fixing.

Figure 8 is the 'arcading' at the west end of the Lady Chapel at Ely Cathedral, and I know no masonry more satisfying than this superb piece of fourteenth century work, with its pure jointing and extremely beautiful mouldings and other details. It is a good illustration of stooling, that is, the piece of stone left in the solid with the sill, to form a horizontal bed for the mullion or jamb to stand on.

The highest skill of the mason's craft is shown in his vaulting, the earliest form of which is the simple barrel—or single-arch vault. To form this, as indeed for all vaults, he must have a centre or reverse shape in wood on which to place his previously-worked stone. After the last stone is fixed and the mortar allowed to set for a time the wood is removed and the stone carries itself. The intersecting barrel vault is a much more complicated work, indeed I think it more difficult to do than elaborate rib vaulting because of the ever-changing angle of the diagonal arris.

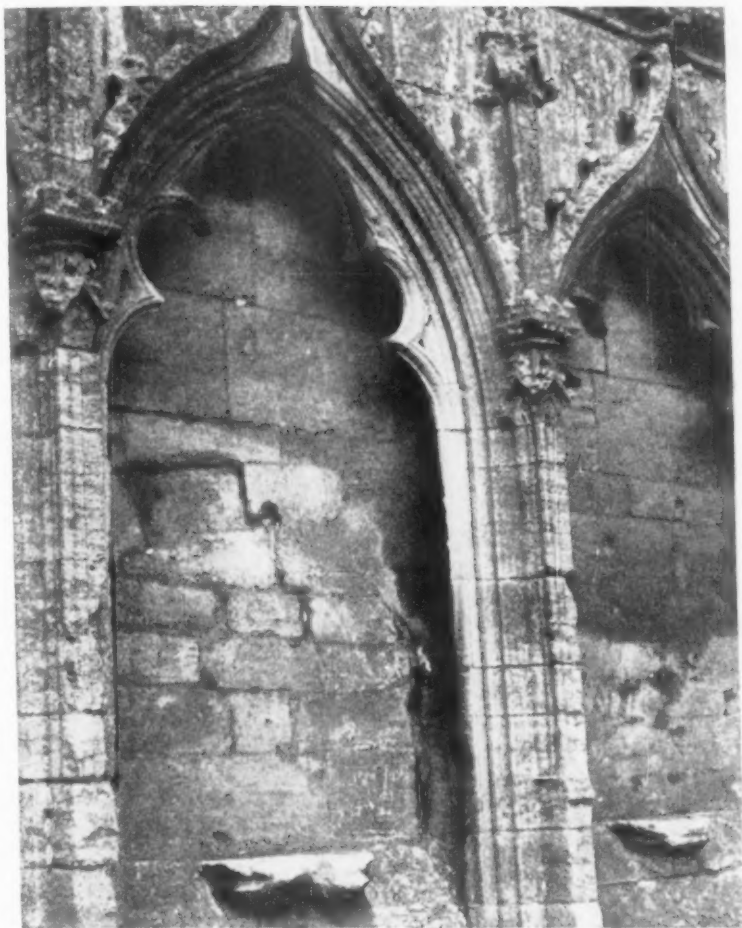


FIGURE 8. *Ely Cathedral, Lady Chapel*

The difficulty of setting out a true mason's vault of this type was the reason for so many vaults of Norman date being formed in small rough stones without much attempt at forming radiating joints. In such cases the finished surface was made out in plaster and the diagonal arris emphasized near the apex.

In a normal rib vault, or a fan vault, the carpenter plays a great part. From the mason's setting out, he forms wood ribs or centres, on which the stone ribs are laid. The bottom stone, called the springer, is generally in one piece, with the required number of ribs worked on it. This particular stone is taken well into the thickness of the wall to act as a corbel to take the weight of the vault as low down as possible. On each side of the back of the stone ribs, a rebate is formed and in these the thin panel stones called the web are laid.



FIGURE 9. *Jesus College Chapel, Cambridge*

There is naturally a great deal of thrust from a stone vault hence the great buttresses used outside the walls for support. Pinnacles above such buttresses are not there for decoration only, though they have great æsthetic skyline value. Their weight adds much to the stability of the buttress in counteracting vault and roof thrust. An arch without weight above it is not very secure, particularly a four-centre arch, and a vault, being after all a series of arches, is subject to the same defect. To obviate this trouble, the pocket formed where the vault ribs intersect at the springers is filled with rubble or rough masonry to give the needed back support.

The south wall of Jesus College Chapel, Cambridge (Figure 9) shows the original thirteenth-century arcade buried within the fifteenth-century filling.

The ashlar filling of this later date was rendered with Roman cement about a hundred years ago. Roman cement was at least as good as the hard cement or so-called synthetic stone used to-day, but the usual cracks developed, water got in, the frost came, and the last stage was worse than the first. That stage being reached, the stone began to deteriorate more quickly than if it had not been rendered. I believe it is far better to leave stone exposed externally and rely on good pointing, only replacing by natural stone those stones which have gone too far. For the pointing, particularly for wide joints, crushed flint, sand and lime seems to give the best results. The Saxon Tower of St. Benets Church, Cambridge, is a good instance of this treatment.

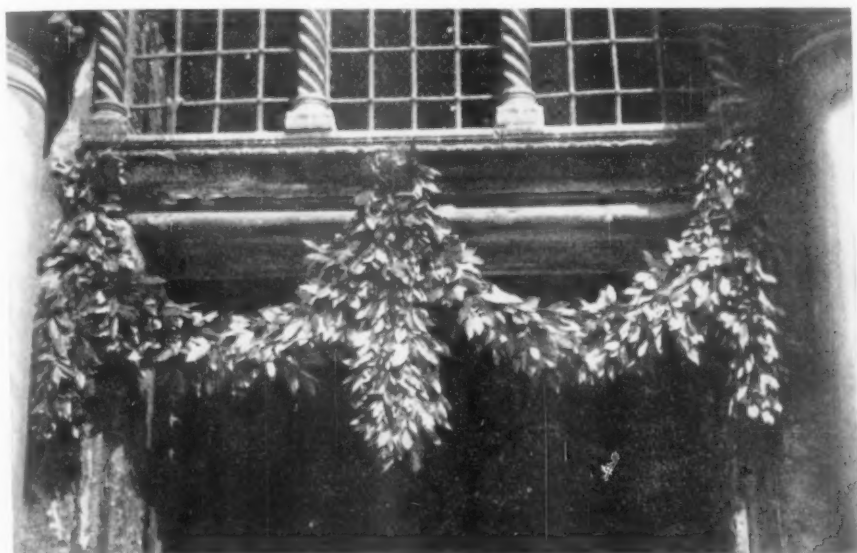


FIGURE 10. *Real laurel at St. Mark's, Venice*

Of the many problems the mason has to face, one is the preparation of stone or marble for carving and the skill he uses in doing this is almost unbelievable. Throughout the ages he has had to form stone and fix it in such a way that it can be carved to look like natural flowers or leaves. Some of the carving in Roman times, and again in later periods, was just like natural foliage. In the early decorated, and Italian Renaissance periods, and in Sir Christopher Wren's time, natural ornament was used with great effect. I give Figure 10, which shows real laurel festoons hanging above a doorway at St. Marks, Venice, just to demonstrate the resemblance between real foliage and carved work. Contrast this with Figure 11 (overleaf), the corbels at Norwich Cathedral, where conventional work is taken to the greatest and simplest extent. These corbels are simply moulded shapes with eyes cut in with the smallest possible effort and lowest possible cost.



FIGURE 11. *Norwich Cathedral, stone corbels*

So far I have said little about the mason's actual work. Masonry is one of the few crafts still carried out in almost the same way as in its earliest days. We know that the circular diamond or carborundum saw has facilitated reducing the rough quarried blocks to squared shapes, and lately machines have been used for moulding or for forming large smooth surfaces where a great quantity warrants it but, in the main, the mason does his work with mallet and chisel.

Every kind of stone has its most economical and best-looking face texture. Very soft stones are finished with a drag, that is, a piece of steel with notches cut into it like a saw. Medium stones, such as Clipsham are best finished with a tooled face. In Victorian days, when 'finished with a tool face' was specified,

the masons used to rub the surface first and then chop in tool marks. Nothing could look more false than this and it was difficult to get masons onto the right track again. We finally achieved this by asking a mason to chisel off a piece of stone to a plane and then saying to him, 'now leave it, that is just the effect wanted'. Very hard stones are finished by rubbing the surface with a grit stone and they can be polished by rubbing with finer stones.

For the highly-skilled mason the quickest and best way to form the rough shape is to use a point tool. The Greeks used this method, and it is said that Michelangelo could cut away as much marble in a few hours by this means as three or four young masons could in three or four days.

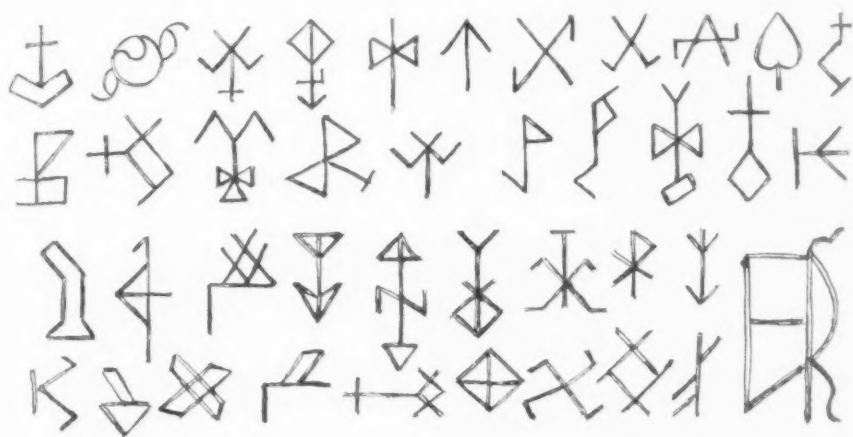


FIGURE 12. *Mason marks, King's College Chapel, Cambridge*

In the past, masons worked in groups or guilds, going about the country where their work was required. Figure 12 illustrates the mason marks on the stones of one Chantry Chapel at King's College, Cambridge. They are very delicately scratched on the face of the stone where they can be seen. This would seem to prove that the mason finished his stone quite truly before it was fixed and did not rely on cleaning down afterwards. The mason mark at the bottom right-hand corner is natural size.

In modern masonry, stone is moved about by cranes and other mechanical means, nevertheless the mason still retains his power of dealing with heavy blocks without such help. I remember an instance of two masons fixing a tomb weighing two tons, and after watching them move it about without effort, an interested spectator exclaimed: 'Now I know how they built the Pyramids'.

## GENERAL NOTES

## EXHIBITIONS OF GLASS AND PAINTING

Two outstanding exhibitions of glass, imaginatively presented in their West End settings and so lit, as such displays should be, to enhance every subtlety in the shape or engraved design of the translucent ware, must certainly appeal to many Fellows of this Society. The entrancing exhibition of Steuben glass, an American product renowned for its purity and transparency, remains on view at Park Lane House, 45 Park Lane, until 9th November, to illustrate the range of its artistic possibilities, and with no underlying commercial motive, it appears, since the glass cannot be purchased in this country owing to the import ban on luxury products from the dollar area. Hardly any Steuben glass, indeed, is to be found here outside those Royal homes which possess the Presidential gifts to the Queen and the Queen Mother, who have graciously lent them on this occasion.

The first exhibits to take the eye—in the first of three dim rooms, spot-lit from above, and with concealed lighting irradiating the vessels against their deep blue background—are twenty crystal pieces whose designs by modern British artists have been engraved by American craftsmen. Mr. Graham Sutherland here provides a characteristically stylised *Mantis* for a tall vessel, Professor Robin Darwin a closely knit and rhythmic design entirely apt to its purpose, and Mr. John Minton two charming decorations symbolizing *Day and Night*. In fact, every exhibit testifies to the closeness of the understanding between the workman and the designer who indicated the shape of the piece requisite to his purpose, though that is not to say that every artist has been quite so imaginative, say, as Sir Jacob Epstein, whose exotic and visionary image is most clearly dictated by the nature of the vessel, even its rim playing a vital part. Similarly none of the foreign artists, though these include designers as inventive as Henri Matisse and M. Jean Cocteau, reveal quite the subtlety of M. Pavel Tchelitchev whose acrobats are so cleverly distorted and foreshortened to emphasize the curve of the surface.

From these fragile dishes and vases, their designs floating like vapour wreaths on a crystalline sky, it is no less rewarding to turn to the experimental pieces, developed far beyond traditional glass-making forms. Steuben's designers have, in fact, successfully sought to capture the fluid and mobile nature of brilliant crystal in forms that may correspond, as in Mr. Don Pollard's *Counterpoise*, to contemporary abstract sculpture. This evolution of art in glass is unquestionably the most impressive of the experiments at the Glass Centre in Corning, New York, which embraces the Steuben factory.

The other exhibition, as effectively displayed at the Tea Centre in Lower Regent Street, and illuminated by massive chandeliers, is of Bohemian glass, and includes a number of baroque cut crystal goblets and other historic exhibits. In fact, the fame of Bohemian glass was established in the seventeenth century, when many glassworks were already producing etched and engraved pieces of exceptional quality. No doubt the highest peak in the evolution of Bohemian cut glass was reached in the second quarter of the eighteenth century, when this glass became the most expressive product of the baroque period, the cut ornamentation stressing its peculiar transparency and light effects.

The modern works in the present collection include several table suites as elaborate as that called 'Splendid'—the bowl cut in delicate filigree, with an etched gold border—which was particularly admired when the set was shown at St. James's Palace, among the wedding gifts to the Queen. Though certain table suites, such as 'Maria Theresa', exhibit a very natural tendency to reproduce the exquisite modes of the past, there is evidence enough that Czechoslovak designers are capable of

evolving the simplest and most elegant shapes with due regard to their function. Only so, indeed, could Czechoslovakia occupy, as it still does, a leading place in the glass-producing countries of the world.

When these words appear, the most comprehensive display of Portuguese art ever brought together will be on view at the Royal Academy, and must be considered hereafter. It comes at a moment when a considerable number of Continental exhibitions are to be seen in the West End galleries, though none of these, it may be said, is of outstanding importance. Mme. Germaine Richier, a fashionable sculptor of the School of Paris who owes a debt to others beside Giacometti, at present fills the Hanover Gallery with fantastic creatures in bronze or lead that might be thought highly sinister if they did not, in fact, suggest a rather commonplace imagination. Some other collections from abroad might be mentioned if two rewarding exhibitions of British painting did not have a prior claim on one's attention.

The absorbing collection at the Whitechapel Art Gallery, retrospective of Mr. Michael Ayrton's work done over the past ten years, is one to which, but for illness, I should have drawn attention before. The diverse gifts of this painter, scholar, satirical writer, debater, and more recently sculptor, are known to this Society, which indeed he has addressed on the subject of Giovanni Pisano's sculpture. So nimble an intellect and versatile an achievement might be regarded with our customary suspicion if the Whitechapel exhibition did not demonstrate beyond doubt his high seriousness of purpose, and graphic and plastic gifts unmatched by any British artist of his generation. Never before, as it happens, has this gallery devoted its huge space to an artist as young as 34, filled it so variously, or attracted so thoughtful a stream of visitors from art experts to its neighbouring barrow-boys.

The exhibition shows Mr. Ayrton's development not, as might have been expected, from 1940, but from the end of the war when he was still one of the neo-romantic group. In his pictures called *The Passion of the Vine*, a series which occupied him some years later, his painting was still heavy with subjective meaning, though his *Quattrocento* researches were now inducing him to reconcile the disquieting mood of the romantic with a classical and carefully calculated ordering of his *dramatis personæ*. Beside his essays in this kind, there are more recent still-lives, a remarkable portrait of Mr. Wyndham Lewis among others, and bronze sculptures of acrobats and bathers, muscular and clear-cut in design, that seem a logical extension of his drawing. It is a most impressive collection, more various even than has been indicated, that remains on view until 30th October in the gallery adjoining Aldgate East Station.

Finally a word about the exhibition by eight British painters at the Institute of Contemporary Arts. Mr. Peter Snow, one of the two most interesting artists in this company, may be remembered for his theatrical designs for *Waiting for Godot* and *The Buccaneer*, though he was a Slade School student only quite recently. His three easel pictures of a conservatory exhibit an unusual control and lucidity, his intention of imposing order on a confusion of pot plants at difficult levels, without a single focus, being exactly realized in paintings that might suggest the influence of Matisse. The other young painter of significance here is Mr. Michael Andrews, also from the Slade, who was awarded the Rome Prize for painting two years ago. Since then the number of paintings this infinitely conscientious artist has produced might be counted on the fingers of one hand, so that the appearance of his *Four people sunbathing* is therefore of particular interest to students of contemporary art. He has conceived a party of men who have plumped themselves down unceremoniously, as he puts it, but formally with respect to their garden surroundings. It is an extremely interesting arrangement, planned with architectural precision while achieving an informality of pose, though the forms might well be more solid than they are, and very natural signs of the artist's immaturity are observable elsewhere.

NEVILLE WALLIS

## TRAFALGAR ANNIVERSARY COMMEMORATIVE MEDAL



*The Nelson Medal by Paul Vincze, struck to commemorate the one hundred and fiftieth anniversary of the Battle of Trafalgar; obverse and reverse (actual size)*

Fellows will recall that one of the objects of the Society's Exhibition of European Medals, 1930-1955, was to encourage a revival of the practice of striking medals to commemorate important events. Now, on the one hundred and fiftieth anniversary of the Battle of Trafalgar, which occurred on 21st October, such a medal has been designed by Paul Vincze who, as will be remembered, participated in the Exhibition. The medal, reproduced above, has been struck by Messrs. Spink & Son, from whom further information can be obtained. It is to be sold (though not exclusively) at or through the National Maritime Museum at Greenwich, who will receive a percentage of the proceeds for the 'Save-the-Victory' Fund.

## INTERNATIONAL AFFAIRS AND THE UNIVERSITY

International Relations as a distinct subject of undergraduate study at the University has had a relatively short history in Britain. It is, in fact, a child of the First World War, an event which appeared to indicate the need for better public understanding of matters having potentialities for making civilized life impossible. Not until 1919 was the first Chair in International Relations created. This was at Aberystwyth and it was due, not to any decision by the University authorities, but to the munificence of a private individual, Lord Davies, a Welsh industrialist. It was left to another industrialist, Sir Montague Burton, to found the Chairs at Oxford and London, and subsequently at Edinburgh in 1948. Only at Aberdeen University has provision for teaching International Relations been made on the initiative of a university itself; this was in 1949 when a lectureship in the subject was established. Among these five centres it is chiefly in London that International Relations is recognized to be essentially distinct from International History and Public International Law, although its close affiliation with those two older disciplines is fully acknowledged there; elsewhere a predominantly historical or legal approach to international affairs is preferred. For this reason, and because the writer is best acquainted with conditions in London, it is with the ideas on the subject prevailing in that University, and especially at the London School of Economics, that this article is concerned.

The outstanding feature of the teaching of International Relations at the London

School of Economics is the assumption that it constitutes a separate academic discipline and needs to have an autonomous existence within the University curriculum; that it is a grown man, so to speak, with a personality of its own, which can best be expressed within a house of its own. This claim is by no means universally acceded to in this country, as is evident from the meagre provision for the subject already referred to. Even an incumbent of the Chair at Oxford before the war, a scholar of distinction in this field, Sir Alfred Zimmern, denied at a conference of teachers of the subject in Prague in 1938 that International Relations could be regarded as a subject in its own right. 'From the academic point of view', he explained, 'International Relations—is clearly not a subject in the ordinary sense of the word. It is not a single subject but a bundle of subjects'. And he proceeded to specify the well-established subjects from which he considered the *fascies* of International Relations were compounded.

On any unprejudiced view it would seem that two conditions need to be satisfied before a claim to departmental independence on behalf of any academic subject can be made out, the question of whether a particular university is financially able or otherwise free to fulfil such a claim naturally being excepted. In the first place, there requires to be a recognizably distinct, though not isolated, set of human relations 'out there' in the world, which is not in itself the subject of any existing academic study and which is of sufficient human interest or social importance to merit a place in the work of higher educational institutions. The case for International Relations is grounded in the proposition that there does indeed exist a unique realm of social being, that made up in the first instance not of individual human persons but of sovereign states, and that this diplomatic world has its own goals, its means, methods and techniques, its own behaviour patterns, standards of conduct, moralities, systems of law. These incidents of state behaviour are by no means precisely the same as the corresponding characteristics of other social aggregates, and are in practice only partially or obliquely treated by historians, economists, geographers, lawyers.

This is not to say that the frontiers of the affairs of international society can be sharply differentiated from those of the internal affairs of states, or that the mutual relations of states are unaffected by the relations between individuals living under a common government within a particular state. But it is the assertion that the relations of sovereign states with one another form an entirety which is *sui generis*, and that the different influences at work on these relations, in all their variety, are not at present comprehensively or deliberately treated under the heading of any other subject. Most emphatically these forces challenge understanding to-day, not merely because of the implications of modern warfare, but because almost all activities within the state are to an increasing extent conditioned by the nature of the social world in which the state has to live. The international character of modern life, one may say, is what has put International Relations on the academic agenda.

The other condition to be satisfied by a study proposing to call itself a distinct subject is that, if properly pursued, it should induce in the student something in the nature of a distinct outlook, a recognizable intellectual orientation valuable in itself and affording an understanding of life perhaps more varied and rich than otherwise he might have had access to. The proponents of international studies hold that there is a particular way of looking at the facts of life, an oecumenical or extra-national way, which their subject helps those who pursue it to acquire. It is not that the student will be less of a patriot or will turn into a kind of uncritical zealot for international 'causes'. Undoubtedly, however, he will know more of what the foreign policy of his country is for, of what it is possible for his country to achieve in international affairs and with what limitations the foreign policy of any country, no matter how powerful, is hedged about, and this because he has sought to improve his understanding of the structure and functioning of the society the pressures and counter-pressures of which give rise to foreign policy.

Such contentions as these have of course not gone without challenge in the universities. It has been argued that the field of study proposed, the mutual impact of states, is so wide and necessarily embraces so many different other subjects, from Economics to Social Psychology, that the student can only hope to acquire a surface acquaintance with each of these during his three or four undergraduate years, and that proper mental training cannot be expected from such superficial scholarship. Ultimately, International Relations envelops the collective behaviour of mankind. How, it is asked, can the young man or woman find in such a field the limited, well-defined material on which to sharpen his wits as the candidate for Classical Moderations at Oxford, say, finds it in the textual criticism of Cicero's letters?

Perhaps the most cogent answer to this is that, at the London School of Economics at least, no attempt is made by the teachers of International Relations to teach the entire degree, the B.Sc.(Economics), in which International Relations is an optional special subject, and the degree has not wholly to do with International Relations. The other subjects, Economics, Political History, Political Theory and so on, are taught by authorities in these fields who can be relied upon to impart a more than superficial command of their subjects. What the teacher of International Relations has to do, in such an academic situation, is essentially to show the bearing of these subjects upon his own field of interest, one which, incidentally, is bound to be a concern for the intelligent student whether or not it actually figures in his academic time-table. It is true that International Relations may easily degenerate into superficiality owing to the heroic scope of its interests, but the assumption implicit in the subject is that one needs to have a working knowledge of the general political and social geography of international society before study of more specialized problems can be faced. All too often it is taken for granted that expertise in the facts of international life is a matter of common sense. Very little reflection upon the experience of the last few decades is needed to show how unfounded is this myth of the native literacy of the common, or even the uncommon, man in matters of international politics.

A second doubt has arisen from the nature of the available documentary material, which is of course voluminous and yet incomplete on vital questions, of varied quality and much of it tendentious and likely to mislead the immature, particularly as international affairs are steeped in powerful emotions and pregnant with self-interested interpretations. The student has before him in London the more responsible British and foreign journals for enlightenment on current international problems and the writings of such authorities as E. H. Carr, H. J. Morgenthau, Quincy Wright, J. L. Brierly, for an introduction to the more permanent ingredients in his subject. But the inescapable influences of time and place, even in such literature, necessitates in the undergraduate powers of discrimination on the threshold of his studies which it has been said it is optimistic to look for. Yet this is a criticism which one is tempted to say applies with hardly less force to History, for all its appearance of being factual and definitive. No small proportion of primary historical documents is equally tendentious and there can be few periods of the past in relation to which historical 'truth' is not constantly in process of revision. On this very ground indeed historical study is often recommended, as strengthening the student's power to evaluate evidence, to weigh against each other conflicting versions of the past, and no less may be said of study of the present world of international relationships. True, the scholarly literature on international relations in any language is still exiguous. The subject has yet to find its Adam Smith, its Hobhouse or Malinowski. But these writers in their own day assuredly did not await predecessors before dedicating themselves to their inquiries. They saw questions to be answered, circumstances to be accounted for, and it was the imperatives of their intellectual task, rather than its contemporary standing, which drove them towards their achievement.

These two objections combine in the great question of who is going to be entrusted

with teaching such a subject? What sort of training should he himself have had, what methods should he adopt, and if it is out of the question to employ a team of teachers, parcelling out the ground among themselves, is it possible for one man to cope with it single-handedly? If a teacher undertakes to treat International Relations with the integrity usually called for in a university obviously he needs must be something of a superman, both on account of the extensiveness of his province and on account of the need for him to inhibit his personal predilections on questions almost all of which run deeply into philosophy and ethics. The problem is complicated by the fact that, International Relations being a comparatively new subject, most of those teaching it in this country to-day had no opportunity to graduate in it themselves. This aspect of the staffing problem may well solve itself in time, provided the universities permit themselves to entrust graduates in the subject with such few posts in this field as become available. But it will always be incumbent upon any teacher in this field to avoid giving the impression that what he deals out in his lecture-room is 'final truth'. Ideally, his duty is not so much to teach, in the sense of expounding his subject as the Professor of Ancient History unfolds his theme to a class of beginners, but to facilitate in his charges a more self-critical attitude towards their own understanding of the subject. It is assumed that the student comes to International Relations equipped with some conception of international life. A Department of the subject is there, not to superimpose upon this conception another, condensed from the text-books and verbalized, but to provoke the student into scrutinizing it and discovering how far it adequately describes the real world of inter-state relationships.

One may now turn to the second principal characteristic of the subject as it is handled in London, namely the cardinal distinction that is drawn between three things: the international environment; states, as the dominant creatures inhabiting this environment, the chief animals in the Zoo, as it were; and the relations occurring between these entities in this environment. These are the three basic components in the scheme.

The premise underlying the organization of teaching at the London School of Economics is that, just as the living organism has to adjust to its environment in order to survive and prosper, and its anatomy and all its movements are conditioned by the circumstances of climate and natural habitat in which it lives, in much the same way the behaviour of states is primarily to be explained in terms of the nature of the world society in which they find themselves. Indeed, it is not an exaggeration to say that foreign policy is called for only because means have to be found to put the state into communication with its world social environment. A change of political *régime* in a country may result in a change in its foreign policy, but the foreign policy of whatever *régime* has for its objectives the exerting of an influence of some kind upon the existing relations between the country and its neighbours, and therefore has to work upon a situation which to a very large extent comes ready-made from abroad. It is interesting to see in this connection that the pretensions which have issued from time to time from revolutionary political *régimes* that they are able to alter the basic character and procedures of international society have generally in course of time given way to foreign policies in their more traditional forms. Barrington Moore, for example, in his absorbing book *Soviet politics: the dilemma of power*<sup>1</sup> has shown how the Russian Communists were obliged, chiefly by the exigencies of the sort of world they lived in, to revise the chiliastic character of their ideology and adopt the traditional techniques of statecraft in the handling of their relations with external states. The Communist ideology has become more 'manipulative' than 'directive', more useful for winning the masses than for guiding the leadership. It may be that radical political changes within a country revolutionize the spectrum through which the world outside is perceived, but there are nevertheless certain

<sup>1</sup> Cambridge, Mass., 1950.

constants in international politics, exercising a conservative influence upon politics within the state and corresponding to the distinctions drawn above: the geographical siting of the various states; the behaviour and attitudes of other states; the restless competition for influence and authority.

It is important to insist that this is far from being a deterministic conception of international affairs. It does not imply that a country has no choice but to follow the characteristic patterns for protecting interests and safeguarding its life that are implicit in the nature of international society. A people may revolt emotionally against international politics and determine to have as little to do with them in the future as possible, as did the United States in the period between the two wars. Or there may be a substantial demand in a country, as in Britain during these same years, that it should cut adrift from traditional diplomacy, with its armaments, its alliances, its balancing of power, and put in place of these a new variety of multi-lateral diplomacy under a League of Nations, in which world opinion would decide the shape of things and not the relative weight of states bargaining against one another for position. Or there may be the upsurge in a country of the belief that international politics should conform to the same rules of conduct as private life, followed by some attempt to apply this maxim in practice. Such revolutions against the usages and implicit logic of international society are indeed possible, and it is the business of the historian to provide us with an account of them.

It is a fact, nevertheless, that so far most of these attempts to substitute new principles of foreign policy have disappointed expectations, and that their exponents, once they have attained to power, have usually been seen to act in a manner surprisingly like that of their predecessors. It is not so much that corruptions of office have caused them to fall away from their lofty ideals, but that the nature of the society, that unique complex of social forces in which they have been operating in their foreign policies, has proved superior to their revolutionary protest. To revert to the three examples of departure from traditional practice already cited: the Americans, having retired in umbrage from world politics in 1919, found themselves, from 1941 onwards, obliged to take a hand in international relations like any other great state, to play a hand in diplomacy like any other state and to learn, often from the others, how to do it well. Advocates of the League who in the 1920s called for the mobilization of world opinion for the disciplining of peccant states found in the 1930s that defence of the Covenant meant the organization of a bloc of states against the totalitarian bloc, a camp against a camp, the whole notion of which they had renounced with loathing before. Woodrow Wilson, the classic exponent of the assimilation of public with private norms of conduct, found himself constrained to lower his sights at the Paris Peace Conference and to take part in some rather dubious dealings there in order to achieve his dream of giving birth to the League. It is the work of historical study, as has been said, to illuminate what men and states do with the international system of politics. The province of International Relations is to explain that such a system exists, that it persists notwithstanding historical vicissitudes, and that to its procedures every responsible Government is obliged, late or soon, to pay heed if it wishes to realize its expectations from international society: security, welfare, influence. There is, in short, a discernible logic in the international system, which states can hardly fail to observe, whatever they are seeking to do. It is this logic, not static indeed, but stable enough to form the focus of a humane study, which bulks large in the subject-matter of International Relations.

It will be seen from this necessarily brief account that the title of International Relations to an assured place within the universities has powerful arguments in its support, and that the problems of method it raises are as much a challenge to the academic world as reason for hesitation in making wider provision for its study. Certainly its social utility is hardly open to question: the existence of us all is patently dependent upon the informed judgment that is exercised in a world in which order

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is not imposed by a single sovereign but distils from the complex interactions of separate powers. What is being attempted at the London School of Economics is an experiment worthy of close study by all who appreciate the pertinence of these claims.

F. S. NORTHEGE

#### EXHIBITION OF ANTARCTIC WATER COLOURS

An Exhibition of Water-colour Paintings, executed in the Falkland Islands by Roger Banks, is at present on view at the Imperial Institute, South Kensington. The artist recently spent two and a half years as a weather observer in the Antarctic, and his paintings portray the various seasons in the region.

The Exhibition is open from 10 a.m. to 4.30 p.m. on weekdays and from 2.30 to 6 p.m. on Sundays. Admission is free.

#### SHORT NOTES ON BOOKS

HOW TO USE CREATIVE PERSPECTIVE. By E. W. Watson. New York, Reinhold; London, Chapman & Hall, 1955. 60s

By examining a series of illustrations, Mr. Watson helps the artist, draughtsman or illustrator to solve problems of perspective. There is much information about the various techniques involved, and the book is copiously illustrated.

GOOD SIR TOBY. By Desmond Eyles. Doulton & Co., Ltd., 1955. 30s

Comparatively few toby jugs made in the eighteenth century have survived, but in *Good Sir Toby* the author is mainly concerned with the modern productions of the Royal Doulton Potteries. It is to the collector of these specimens that this book, which has many illustrations, is directed.

#### FROM THE JOURNAL OF 1855

VOLUME III. 19th October, 1855

PARIS EXHIBITION

\*Economic Gallery

(From the *Moniteur* of 1st October)

His Imperial Highness Prince Napoleon yesterday visited this recently formed department of the Exhibition . . . .

The idea of such a gallery as this, it is well known, had its origin in the Society of Arts of London, and received from the first great encouragement from the Emperor and Empress, and has been just put into practical operation by H.I.H. Prince Napoleon.

The gallery is specially devoted to the display of objects which minister to the daily wants of life, and which by their cheapness, good quality, and utility, are fitted to promote the well being of the masses.

These objects are arranged under four separate heads or groups, classed according to the purposes for which they are intended.

The first contains alimentary substances and substances used for heating, lighting, and washing.

The second includes furniture and articles for household use.

The third contains textile fabrics of every description, linen, ready-made clothes, and everything connected with dress.

The fourth shows examples of apartments, with specimens of the furniture fitted for each description of room.

\* 'Economic' is here used in its old sense of 'low priced'.

His Imperial Highness has long had his attention fixed on this first attempt at an exhibition of domestic economy, and he has repeatedly expressed his great satisfaction that France should have had the good fortune to initiate it, and his firm belief that her example cannot fail to be followed in future exhibitions.

For more than an hour the Prince remained in the gallery, examining minutely all the most interesting articles. He made many inquiries as to the mode of manufacture, the hand-labour employed, the rate of wages, and the price for sale, and thus showed how much importance he attached to the means of increasing the well-being of the many, and to the bringing the first necessities of life within the reach of all by cheapening their supply. But whilst encouraging cheapness, the Prince pointed out the danger which would result to industry if it were obtained by lowering the wages, and thus injuring the condition of the workman, curing one evil by producing another still greater. In his Imperial Highness's views, true cheapness results not merely from lowness of price, but more particularly from improvements which, by rendering the article more lasting, more commodious, and more easy to keep in repair, produce for those who use them a daily saving of time and money.

### PURCHASE TAX ON MEDALS

Since the first part of this issue went to press the Chancellor has opened the autumn Budget, which has freed gold and silver medals from Purchase Tax. A fuller note will be published in the next *Journal*.

### Some Activities of Other Societies and Organizations

#### MEETINGS

MON. 31 OCT. Geographical Society, Royal, South Kensington, S.W.7. 8.30 p.m. Sir Miles Thomas: *Problems and Prospects of World Airline Development*. Imperial Institute, South Kensington, S.W.7. 5.45 p.m. M. J. Forster: *The Man on the Spot: British Solomon Islands*.

TUES. 1 NOV. Incorporated Plant Engineers, at the Royal Society of Arts, W.C.2. 7 p.m. E. J. Bradbury: *Corrosion of fouling in industry*.

Manchester Geographical Society, 16 St. Mary's Parsonage, Manchester, 3. 6.30 p.m. H. A. Lingwood: *The Port of London*.

Textile Institute, at the Town Hall, Morley, 7.15 p.m. G. Marshall: *Controlled Carding: the Woolen and Worsted Carding Machine of the Future*.

WED. 2 NOV. Victoria & Albert Museum, South Kensington, S.W.7. 6.15 p.m. Winslow Ames: *Early Victorian Taste*.

THURS. 3 NOV. Wood Education Society, at the Royal Society of Arts, W.C.2. 7 p.m. Dr. W. G. Hoskins: *Sheep Farming in Saxon and Medieval England*.

SAT. 5 NOV. Horniman Museum, London Road, Forest Hill, S.E.23. 3.30 p.m. Wilfred Smith: *Playing and Talking about Flutes*.

MON. 7 NOV. Engineers, Society of, at the Geological Society, Burlington House, W.1. 5.30 p.m. C. W. E. Dudley: *Investigation into the Design of Super-structure of a Power Station*.

Geographical Society, Royal, at the Royal Festival Hall, 8.30 p.m. Charles Evans and George Band: *Kanchenjunga Climbed*.

Imperial Institute, South Kensington, S.W.7. 5.45 p.m. J. M. B. Hughes: *The Man on the Spot: Malaya*.

TUES. 8 NOV. Illuminating Engineering Society, at the Lighting Service Bureau, 2 Savoy Hill, W.C.2. 6 p.m. F. Jackson: *Efficiency of Fluorescent Lamps*. Manchester Geographical Society, 16 St. Mary's Parsonage, Manchester, 3. 6.30 p.m. Geoffrey North: *The Rossendale Valley*.

Mechanical Engineers, Institution of, 1 Birdcage Walk, S.W.1. 5.30 p.m. F. G. Parnell and E. J. Bradbury: *Disc Brakes*.

WED. 9 NOV. Engineering Inspection, Institution of, at the Royal Society of Arts, W.C.2. 6.45 p.m. G. Bird: *Quality Control during High Speed Diesel Engine Manufacture*.

Fuel Institute of, at the Institution of Civil Engineers, Great George Street, S.W.1. 5.30 p.m. J. E. Hawkins and G. Nonhebel: *Chimneys and the Dispersal of Smoke*.

Petroleum Institute of, at 26 Portland Place, W.1. 5.30 p.m. Prof. F. H. Garner, G. H. Grigg, Prof. I. Morton and W. D. Reid: *Pre-flame Reaction in a Diesel Engine*.

Victoria & Albert Museum, South Kensington, S.W.7. 6.15 p.m. Beatrice Playne: *The Rock Churches and Medieval Art of Ethiopia*.

THURS. 10 NOV. Electrical Engineers, Institution of, Savoy Place, W.C.2. 5.30 p.m. T. H. Kinman, G. A. Carrick, R. G. Hibberd and A. J. Blundell: *Germanium and Silicon Power Rectifiers*.

SAT. 12 NOV. Horniman Museum, London Road, Forest Hill, S.E.23. 3.30 p.m. Mrs. Rodney Gallop: *Mexican Fiesta*.

#### OTHER ACTIVITIES

MON. 31 OCT. UNTIL SUN. 6 NOV. Imperial Institute, South Kensington, S.W.7. 12.30 p.m., 1.15 p.m. and 3 p.m. Weekdays, 3 p.m. and 4 p.m. Saturdays, 3 p.m., 4 p.m. and 5 p.m. Sundays. Films: *Cave Temples (part 2)*—India; *Rhodesia Spotlight No. 23*; *Mr. Menzies on the Commonwealth*; *Yoho Wonder Valley*.

MON. 7 NOV. UNTIL SUN. 13 NOV. Imperial Institute, South Kensington, S.W.7. 12.30 p.m., 1.15 p.m. and 3 p.m. Weekdays, 3 p.m. and 4 p.m. Saturdays, 3 p.m., 4 p.m. and 5 p.m. Sundays. Films: *Winter in Quebec*; *Rhodesia Spotlight No. 24* *Enchanted Isle—Ceylon*.

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